PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year)	
09 November 2000 (09.11.00)	

International application No.	Applicant's or agent's file reference
PCT/SE00/00514	MH/ARI 43263

International filing date (day/month/year)	Priority date (day/month/year)
16 March 2000 (16.03.00)	19 March 1999 (19.03.99)

Applicant

BORÉN, Thomas et al

1. The designated Office is hereby notified of its election made:

    [X] in the demand filed with the International Preliminary Examining Authority on:

    16 October 2000 (16.10.00)

    [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

    [ ] was not

    made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer R. E. Stoffel
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
MH/ARI 43078		

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/SE00/00514	16.03.2000	19.03.1999

International Patent Classification (IPC) or national classification and IPC7
A 61 K 31/702, A 61 K 31/715, A 61 P 1/04

Applicant
Borén, Thomas et al

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of ____5____ sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
16.10.2000	03.07.2001

Name and mailing address of the IPEA/SE	Authorized officer
Patent- och registreringsverket Telex Box 5055 17978 S-102 42 STOCKHOLM PATOREG-S Facsimile No. 08-667 72 88	Eva Johansson/EÖ Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE00/00514

I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:

pages _____ , as originally filed

pages _____ , filed with the demand

pages _____ , filed with the letter of _____

☐ the claims:

pages _____ , as originally filed

pages _____ , as amended (together with any statement) under article 19

pages _____ , filed with the demand

pages _____ , filed with the letter of _____

☐ the drawings:

pages _____ , as originally filed

pages _____ , filed with the demand

pages _____ , filed with the letter of _____

☐ the sequence listing part of the description:

pages _____ , as originally filed

pages _____ , filed with the demand

pages _____ , filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/ or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

** Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.

Form PCT/IPEA/409 (Box I) (January 1998)

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application,

☒ claims Nos.   8-12, 14

because:

☒ the said international application, or the said claims Nos.   8-12, 14
relate to the following subject matter which does not require an international preliminary examination *(specify)*:

See PCT Rule 67.1.(iv).: Methods for treatment of the human or animal body by surgery or therapy, as well as diagnostic methods.

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. _____
are so unclear that no meaningful opinion could be formed *(specify)*:

☐ the claims, or said claims Nos. _____ are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for said claims Nos. _____

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

| V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement |

1. Statement

Novelty (N)	Claims	1-7, 13	YES	
	Claims		NO	
Inventive step (IS)	Claims	1-7, 13	YES	
	Claims		NO	
Industrial applicability (IA)	Claims	1-7, 13	YES	
	Claims	8-12, 14	NO	

2. Citations and explanations (Rule 70.7)

The claimed invention relates to the use of fucosylated sialylated N-acetyl lactosamine structure such as sialyl-Lewis antigen carbohydrate structure for the preparation of a medicament for the treatment of or prophylaxis of infections caused by Helicobacter pylori and related pathogens of the human gastrointestinal mucosa.
The sialyl-Lewis antigen is chosen among sialyl-Lewis x and sialyl-Lewis a.

The problem to solve in the present application is to find clinically significant and efficient substances that influence bacterial adherence and in particular the adherence of Helicobacter pylori, a prevalent pathogen in humans, to the human gastric mucosa. This is achieved with the present invention defined in the claims.

The following documents are cited in the search report:
D1) WO 9500527
D2) Virchow Arch, Vol. 433, 1998, page 419-26
D3) WO 9523605
D4) Science, Vol. 262, Dec. 1993, page 1892-95

D1) relates to fucosylated glycosides, which are inhibitors of infections caused by Helicobacter pylori and related pathogens of the human gastrointestinal mucosa.

D2) relates to Helicobacter pylori infection, which produces reversible glycosylation changes to gastric mucins.

D3) relates to oligosaccharides, which can be used for treating or inhibiting gastric and duodenal ulcers and Helicobacter pylori infections.

.../...

Form PCT/IPEA/409 (Box V) (January 1998)

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V

D4) relates to fucosylated blood group antigen Lewis b and H-1, which mediates Helicobacter pylori attachment to human gastric mucosa.

There is no information in the cited documents about the use of fucosylated sialylated N-acetyl lactosamine structure such as sialyl-Lewis antigen carbohydrate structure for the treatment of infections caused by Helicobacter pylori and related pathogens of the human gastrointestinal mucosa.
Thus, the claimed invention differs from the state of art.

Consequently, the cited documents only disclose the general state of the art, and are not considered to be of particular relevance.

Claims 8-12 and 14 relate to the treatment of diseases. Claims of this kind may be accepted and examined in some countries. However, owing to the difference in the national practice and laws, it is not possible for the International Preliminary Examination Authority to give a statement on such claims that would be equally valid for all states. The consideration thereafter given must therefore be based on the acceptance on such claims according to national legislation.

PCT

(51) International Patent Classification 7 : A61K 31/702, 31/715, A61P 1/04	A1	(11) International Publication Number: WO 00/56343
		(43) International Publication Date: 28 September 2000 (28.09.00)

(54) Title: USE OF FUCOSYLATED SIALYLATED N–ACETYL LACTOSAMINE CARBOHYDRATE STRUCTURES FOR INHIBITION OF BACTERIAL ADHERENCE

(57) Abstract

A fucosylated sialylated N–acetyl lactosamine structure such as a sialyl–Lewis antigen carbohydrate structure, for example sialyl–Lewis x and in particular dimeric or repetitive sialyl–Lewis x can be used for the preparation of a pharmaceutical composition for the treatment or prophylaxis in humans of conditions involving infection by *Helicobacter pylori* and related pathogens of the human gastrointestinal mucosa. Further, said conditions can be treated through the administration of a fucosylated sialylated lactosamine structure, such as a sialyl–Lewis antigen carbohydrate structure or corresponding antibodies to patients in need thereof.

Use of fucosylated sialylated N-acetyl lactosamine carbohydrate structures
for inhibition of bacterial adherence

The present invention relates to the use of at least one fucosylated sialylated N-
acetyl lactosamine carbohydrate structure, such as sialyl-Lewis antigen carbohydrate structure
for the preparation of pharmaceutical compositions for the treatment or prophylaxis in
humans of conditions involving infection by *Helicobacter pylori* or related organisms in the
human gastrointestinal mucosa, as well as a method of treating such conditions using
fucosylated sialylated lactosamine structures, such as said sialyl-Lewis antigen carbohydrate
structures.

Background of the invention

H. pylori, the human specific gastric pathogen, has emerged as the causative
agent in chronic active gastritis and peptic ulcer disease. The chronic infection has been
correlated to the development of gastric cancer, one of the most common forms of cancer in
humans (reviewed in M. J. Blaser. *Sci. Amer.* 2, 92, 1996). *H. pylori* colonizes the human
gastric mucosa by adherence to the mucous epithelial cells and the mucus layer lining the
gastric epithelium. These adherence properties protect the bacteria from the extreme acidity of
the gastric lumen and displacement from the stomach by forces such as gastric emptying.
Central to current thinking in pathogenesis is the importance of adherence for colonization or
disease. Bacteria express adhesion molecules that recognize specific carbohydrates on the
epithelial cell surface and mucin molecules in the mucus lining.

It has previously been demonstrated that the fucosylated blood group antigens
Lewis b and H-1 to mediate adherence of *H. pylori* to human gastric epithelial cells *in situ* (T.
Borén et al., *Science 1993*, 262, 1892). The fucosylated blood group antigens H-1 and Lewis
b are typically found on erythrocytes where they define the O phenotype in the ABO blood
group system, but they are also expressed on the epithelial cell surfaces. A relationship
between histo-blood group antigens and the development of duodenal ulcer has received
attention since the discovery of Aird *et al.* 1954. *Br Med J*, 315, that the frequency of
individuals with blood group 0 is strikingly high in patients suffering from peptic ulcer. The
H. pylori specificity for the Lewis b and H-1 antigens as receptors, could possibly explain the
higher prevalence for peptic ulcer disease in blood group O individuals, since the level of
available *H. pylori* receptors might be reduced in individuals of blood group A and B
phenotypes (T. Borén and P. Falk, *Science* (letter),1994, 264, 1387., T. Borén and P. Falk

2

(1994) *Scientific American, Science & Medicine*, Sept/Oct. 28-37).

The problem underlying the present invention is that of finding clinically significant and efficient substances that influence bacterial adherence and in particular the adherence of *H. pylori*, a prevalent pathogen in humans, to the human gastric mucosa. A

5   further problem is to make available new and efficient methods for the treatment or prophylaxis of *H. pylori* infections.

Summary of the invention

The present invention solves the above problems in that it makes available a

10   novel use of fucosylated sialylated N-acetyl lactosamine glycoconjugates, such as sialyl-Lewis x structures and methods of treatment according to the attached claims.

Description of the figures

The present invention will be described in closer detail below, with reference to

15   the attached examples and figures, in which:

Fig. 1 and **Fig. 7A, B** show bacterial *in situ* adhesion to human gastric mucosa and inhibition assay: *In situ* adherence analysis of the receptor specificity of *H. pylori* (CCUG 17875 and the *babA1A2-* -mutant). Bacteria were pre-incubated with the Lewis b conjugate in 10µg/ml concentration, or the sialyl-Lewis conjugate in 20µg/ml concentration. (A) Section

20   of human gastric mucosa stained with hematoxylin/eosin. (B, C) Non-inhibited *H. pylori* *babA1A2-* mutant and CCUG 17875, respectively, binding to human gastric epithelium. (D, E) Inhibition experiments with Lewis b antigen-, and sialyl-Lewis x antigen-neoglycoconjugate, respectively (F, G).

For Figure 1A-1F, biopsy no.12 (Fig. 7A) was used, with a moderate degree of

25   inflammation cell infiltration. For Fig. 7B, a biopsy no. 9 was used, with less inflammation infiltrate and almost devoid of receptors for the *babA1A2*-mutant.

Reduction in bacterial binding was estimated by counting the number of adherent bacteria in 10 different fields under 200X magnification in two independent inhibition experiments. The control where bacteria were not pre-incubated with

30   glycoconjugates was defined as 100% binding.

Fig. 2 and **7C** show bacterial *in situ* adhesion to mouse gastric mucosa and inhibition assay: In situ adherence analysis of the receptor specificity of *H. pylori*. CCUG 17875 and the *babA1A2-* -mutant. (A) Section of mouse gastric mucosa stained with hematoxylin/eosin. (B, C) Non-inhibited *H. pylori babA1A2*-mutant and CCUG 17875

overlaid on non-transgenic gastric tissue (B, C). and the "Lewis b mouse" transgenic gastric

tissue (D, E), respectively. Inhibition experiments by the "Lewis b mouse" transgenic gastric

tissue with sialyl-Lewis x neoglycoconjugate (F, G), ion concentrations as described in Fig. 1.

5   For Fig. 7C the experimental system was as above, and reduction in bacterial

binding was estimated by counting the number of adherent bacteria in 10 different fields

under 200X magnification in two independent inhibition experiments.

           Fig. 3 shows the results of analyses of *H. pylori* binding to HPTLC separated

sialylated glycolipids: Binding of *Helicobacter pylori* and monoclonal antibodies directed

against sialyl-Lewis x and sialyl-Lewis a to glycosphingolipids on thin-layer chromatograms.

10   The glycosphingolipids were separated and (A) visualised with anisaldehyde. Duplicate

chromatograms were incubated with monoclonal (B) anti-sialyl-Lewis x, (C) anti-sialyl-Lewis

a, and radiolabelled *H. pylori* (D) strain CCUG 17875, (E) the BabA1A2 mutant strain, and

(F) strain CCUG 17874. Autoradiography was for 12 hr. The *lanes* contained: 1, Acid

glycosphingolipids of calf brain, 40 µg; 2, Acid glycosphingolipids of human neutrophil

15   granulocytes, 40 µg; 3, Acid glycosphingolipids of human neutrophil granulocytes after de-

sialylation, 40 µg; 4, Acid glycosphingolipids of human gall bladder adenocarcinoma, 40 µg;

5, Acid glycosphingolipids of human gall bladder adenocarcinoma after de-sialylation, 40 µg;

6, NeuAcα3Galβ4(Fucα3)GlcNAcβ3Galβ4(Fucα3)GlcNAcβ3Galβ4Glcβ1Cer isolated from

human gall bladder adenocarcinoma, 1 µg; 7,

20   NeuAcα3Galβ3(Fucα4)GlcNAcβ3Galβ4Glcβ1-Cer (sialyl-Lewis a hexaglycosylceramide)

isolated from human gall bladder adenocarcinoma, 4 µg; 8,

NeuAcα3Galβ4(Fucα3)GlcNAcβ3Galβ4Glcβ1Cer (sialyl-Lewis x hexaglycosyl-ceramide), 4

µg; 9, Fucα2Galβ3(Fucα4)GlcNAcβ3Galβ4Glcβ1Cer (Lewis b-6 hexaglycosylceramide) of

human small intestine, 4 µg.

25   **Fig. 4** shows characterisation of *H. pylori* receptor specificity with soluble

sialylated conjugates: *H. pylori* strains (see Bacterial Strains and Growth Conditions) were

incubated with ^{125}I-labelled neo-glyco conjugates (See Experimental protocol: Radio

Immuno analyses with neoglycoconjugate receptors). Bars, from the left to the right; The

sialyl-alfa2.6lactose-, sialyl-alfa2.3lactose-, sialyl-Lewis a-, sialyl-Lewis x-, and Lewis b-,

30   synthesised sialyl-Lewis x- sialyl-acetyllactosaminee, both with a either a 3 carbon or 14

carbon (extended/hydrophilic) spacer, conjugated to albumin, Finally, the histo-blood group

antigen Lewis y (synthesised penta-saccharide) (V. Behar and S.J. Danishefsky, *Angew.*

Chem. Int. Ed. Engl, 1994, 33, no. 14, 1468.), was analysed as a neo-glycoconjugate.

Fig. 5 shows a negative ion FAB mass spectrum of the *H. pylori*-binding glycolipid isolated from human gall bladder carcinoma: The molecular ion $(M-H^+)^-$ at m/z 2174 indicates a glycosphingolipid with one NeuAc, two fucoses, two *N*-acetylhexosamines, four hexoses and d18:1-16:0. A series of fragment ions from m/z 2174, obtained by successive

5   elimination of terminal carbohydrate units, are found at m/z 2028 $(M-Fuc-H^+)^-$, m/z 1882 (M-NeuAc-H^+)^-, m/z 1720 $(M-NeuAc-Hex-H^+)^-$, m/z 1574 $(M-NeuAc-Hex-Fuc-H^+)^-$, m/z 1371 $(M-NeuAc-Hex-Fuc-HexNAc-H^+)^-$, m/z 1209 $(M-NeuAc-Hex-Fuc-HexNAc-Hex-H^+)^-$, m/z 1063 $(M-NeuAc-Hex-Fuc-HexNAc-Hex-Fuc-H^+)^-$, m/z 860 (M-NeuAc-Hex-Fuc-HexNAc-Hex-Fuc-HexNAc-H^+)^-, m/z 698 $(M-NeuAc-Hex-Fuc-HexNAc-Hex-Fuc-HexNAc-Hex-H^+)^-$

10   , and m/z 536 $(M-NeuAc-Hex-Fuc-HexNAc-Hex-Fuc-HexNAc-Hex-Hex-H^+)^-$. Thus the glycosphingolipid had a NeuAcHex(Fuc)HexNAcHex(Fuc)HexNAcHexHex sequence, as shown in the formula above the spectrum.

Fig. 6 shows *H. pylori* adherence to immobilized neoglycoconjugates in ELISA: Sialyl-Lewis a-PAA, sialyl-Lewis x-PAA, 3'-HSO3-Lewis a-PAA, and 3'-HSO3-

15   Lewis x-PAA, i.e. synthesised sialylated or sulphated Lewis antigens conjugated to polyacrylamide backbone were added in dilution series of 1μg, 100ng, and 10 ng, to streptavidin coated microtiter plats (ELISA). CCUG 17875 (75) and the *babA1A2* double mutant (DM) were added to the ELISA in a series labelled A-F. Adherent bacteria were detected by polyclonal rabbit antisera against *H. pylori* CCUG 17875. The products of the

20   horseradish peroxidase reaction were quantified in a microtiter plate reader.

Fig. 7A, B, C See Fig. 1.and Fig. 2

Fig. 8 Antibody inhibitions of bacterial binding *in situ*. *H. pylori* CCUG 17875 (75) and the *babA1A2*-mutant (DM) were overlaid on tissue sections pre-treated with monoclonal antibodies against the Lewis b antigen (Lab)or the sialyl-Lewis x (sia-

25   Lex)antigen, and analyzed by *in situ* adherence. Each value is the mean number of adherent bacteria + -SEM of 10 different fields. A comparison between the two different bacterial strains (CCUG17875 *babA1/babA2*-mutant) and control (DM-kon, 75-kon) was performed with the Wilcoxon/Student T-test non-parametric test. P values below 0,05 were considered significant.

30   The following tables are attached to the description:

Table 1, which shows a summary of the results generated in Fig. 3;

Table 2, which shows a summary of results from binding of Helicobacter pylori to glycosphingolipids on thin-layer chromatograms, and

Table 3, which presents the glycoconjugates used in the present study.

Description

The present inventors have now surprisingly identified a new host tissue
carbohydrate receptor, mapped the receptor specificity and affinity and, in addition, found the
presence of the new receptor to be highly correlated with the level of tissue-inflammation,
suggesting an up-regulation of the new *H. pylori* receptor in infected and inflamed
gastrointestinal mucosa. Consequently the use of a specific carbohydrate structure is
disclosed, together with a new method for treatment according to the attached claims. In this
context, conditions involving gastrointestinal infection by *H. pylori* comprise chronic active
gastritis, gastric ulcers, duodenal ulcers, gastric adenocarcinoma, and gastric lymphoma.

In order to characterize and identify the microbial part of the interaction, i.e. the
corresponding histo-blood group antigen binding *H. pylori* adhesin, i.e. the BabA adhesin, the
group combined the technique of affinity purification and crosslinker attachment, and
developed a novel technique; Receptor Activity Directed Affinity Tagging (ReTagging),
allowing the identification and purification of adhesins, (and subsequent cloning/sequencing)
by the biological activity of the Lewis b antigen receptor (D. Ilver and T. Borén et al., *Science*
279, 373, 1998). In order to verify the correct identity of the cloned *babA*-adhesin gene, a
babA-knock out mutant, i.e. a mutant lacking the babA adhesin gene(s) was constructed. This
mutant subsequently lost the binding activity for the Lewis b antigen receptor, and the correct
identity of the cloned babA-adhesin gene could be verified. The experiment was vital since
the BabA adhesin belongs to a family of related and similar outer membrane genes and, in
addition, two separate, but identical alleles of the babA adhesin gene were found (although
only one allele was found to be expressed as a functional adhesin protein). These results were
also published in: Ilver/Borén et al., *Science* 279, 373, 1998. It is proposed that specific
receptor-adhesin mediated *H. pylori* adherence to gastric epithelial tissue plays a critical role
in efficient delivery of *H. pylori* virulence factors that damage host tissue directly, and that
incite inflammatory responses and provoke auto-immune reactions, that cumulatively lead to
development of ulcer disease

The babA knock out mutant described above, lacking the Lewis b antigen
binding properties, turned out to be extremely interesting because the mutant still binds avidly
to the human gastric epithelial lining, in adherence experiments *in situ*, i.e. to histo-tissue
sections of human (biopsy) gastric mucosa. These results suggest the activation of a
complementary adhesin-receptor interaction, for optimal tissue targeting.

Consequently, the present inventors disclose the use of fucosylated sialylated N-acetyl lactosamine carbohydrate structures, such as sialyl-Lewis antigen carbohydrate structures for the preparation of a pharmaceutical composition for the treatment or prophylaxis in humans of conditions involving infection by *Helicobacter pylori* and related

5   pathogens of the human gastric mucosa. In particular, said use in which the sialyl-Lewis antigen carbohydrate structure is capable of binding to adhesins present on the surface of *H. pylori*.

Fucosylated sialylated N-acetyl lactosamine structures are created by expression of alfa1,3fucosyltransferase activities capable of modifying acceptors containing alfa(2,3)

10   sialic acid-substituted lactosamineoglycans, such as Lewis x, Galß1.4(Fucalfa1.3)GlcNAcß1-R (where R is a protein or other carbohydrate structure). The Lewis x antigen is a common trisaccharide structure, which forms the core of this sialylated structure, resulting in sialyl-Lewis x, i.e. NeuAcalfa2.3Ga.ß1.4(Fucalfa1)GlcNAc-R. Another possible structure would be difucosylated sialyl Lewis x, a longer polyfucosylated polylactosamineoglycan, or similar

15   derivatives. It is suggested, that the number of fucose-residues in the core chain affects the affinity and aids in the stabilisation of the receptor-ligand complex/interaction. This interest was further increased by the finding that a binding pattern almost parallel to the pattern of strains CCUG 17874 and the mutant strains was obtained with monoclonal antibodies directed against sialyl-Lewis x (Fig 3, B). The optimal receptor could be of more complex type, as

20   suggested by the slower migrating glycolipid bands that demonstrate high affinity receptor properties in the HPTLC-overlay analyses (Lanes 2 and 4).

A *H. pylori*-binding and anti-sialyl-Lewis x-reactive glycosphingolipid was isolated from the human gall bladder adenocarcinoma (Fig. 3, lane 6), and characterized by negative ion FAB mass spectrometry and ^{1}H NMR as NeuAcHex(Fuc)HexNAcHex-

25   (Fuc)HexNAcHexHex with sphingosine and non-hydroxy 16:0 fatty acid (Fig. 5). Taken together with the anti-sialyl-Lewis x-binding activity a NeuAcα3Galβ4(Fucα3)-GlcNAcβ3Galβ4(Fucα3)GlcNAcβ3Galβ4Glcβ1Cer compound was suggested, *i.e.* a ganglioside with repetitive Lewis x core, previously described in human colonic adenocarcinoma (Fukushi, Y., Nudelman, E., Levery, S.B., Hakomori, S.-i., and Rauvala, H.

30   (1984). Novel fucolipids accumulating in human adenocarcinoma. III. A hybridoma antibody (FH6) defining a human cancer-associated difucoganglioside ($VI^3NeuAcV^3III^3Fuc_2nLc_6$). J. Biol. Chem. *259*, 10511-10517). The binding-active compound was thus a ganglioside with repetitive Lewis x core (Fig. 5).

While almost no binding to sialyl-Lewis a hexaglycosylceramide (Fig. 3, lane 7) was obtained, a weak binding of the CCUG 17874 strain, the BabA2 mutant and the BabA1A2 mutant to sialyl-Lewis x hexaglycosylceramide (lane 8) was occasionally observed. However, this binding required 2 nmol, while the detection level for NeuAcα3Galβ4(Fucα3)-

5   GlcNAcβ3Galβ4(Fucα3)GlcNAcβ3Galβ4Glcβ1Cer was approximately 1 pmol.

The distinct difference in affinity argue for that the monomeric sialyl-Lewis x ganglioside exhibit features required for bacterial binding, while the dimeric or repetitive form is optimised in its presentation of the terminal sialic acid epitope.

At this stage an open question if the increased binding activity is dependent on

10   the repetitive Lewis x element, or due to the longer carbohydrate chain giving optimal exposure of the binding epitope, as has been described for monoclonal anti-sialyl-Lewis x antibodies (Müthing, J., Spanbroek, R., Peter-Katalinic, J., Hanisch, F.-G., Hanski, C., Hasegawa, A., Unland, F., Lehmann, J., Tschesche, H., and Egge, H. (1996). Isolation and structural characterisation of fucosylated gangliosides with linear poly-N-acetyllactosamineyl

15   chains from human granulocytes. *Glycobiology 6*, 147-156).

Further, the present invention comprises a method for treating and/or preventing diseases in humans caused by infection by *H. pylori* of human gastric mucosa, said method comprising administering to a human patient in need thereof an effective amount of a sialyl-Lewis antigen carbohydrate structure.

20   The sialyl-Lewis antigen carbohydrate structure is an antigen chosen among sialyl-Lewis x and sialyl-Lewis a and structurally related carbohydrates. According to a preferred embodiment, the sialyl-Lewis antigen carbohydrate structure is a dimeric or repetitive sialyl-Lewis antigen carbohydrate structure, for example an antigen chosen among dimeric sialyl-Lewis x and sialyl-Lewis a and in particular a repetitive sialyl-Lewis x type

25   structure.

According to another embodiment, exemplified in the attached examples, the bacterial adherence can be influenced by antibodies, raised against the sialyl-Lewis structure. The manufacture of suitable antibodies, either monoclonal or polyclonal antibodies, is well known to persons skilled in the art.

30   A pharmaceutical composition comprising a sialyl-Lewis antigen or corresponding antibody as the main active substance or as one of several active substances can be prepared in a conventional manner, equal to the preparation of other compositions for administration to the gastrointestinal tract. Suitable pharmaceutical vehicles for administration to a patient are known to those skilled in the art.

Said pharmaceutical composition may preferably be administered orally, parenterally or per rectum. It is conceivable that the pharmaceutical composition is given to the patient in drinkable form, comprising suitable constituents such as starches, sugars, fats and waxes and may further include flavouring agents, colouring agents, disintegrants, binders,

5   dispersants etc. It is also conceivable that the pharmaceutical composition is delivered locally to the stomach or duodenum via a stomach tube or nasogastric or nasoduodenal tube. Suitable administration forms include liquid, e.g. aqueous suspensions, as well as solid forms, such as tablets, capsules or suppositories.

For parenteral administration, the sialyl-Lewis x type carbohydrate structure or

10   corresponding antibody can be dissolved or suspended in sterile water or physiological saline solution. For enteral administration, the carbohydrate can be incorporated into an inert carrier and processed to a tablet, capsule or similar form.

Alternatively, the carbohydrate or corresponding antibody can be administered in liposomes or microspheres / microparticles. Methods for preparing liposomes and

15   microspheres for administration to a patient are known to those skilled in the art, and these can be tailored according to need, for example to obtain delayed release or release at a specific location in the gastrointestinal tract, dependent of pH, temperature or the like.

The dosage of the sialyl-Lewis antigen or corresponding antibody depends on the choice of administration route, the particular condition to be treated and the severity of the

20   same, and also whether the disease is to be treated or prevented, as well as the age and weight of the patient to be treated. Finding the optimal dose in each case lies within the normal skills of a practitioner in the field. Importantly, the carbohydrates should be active when administered parenterally or by other means. The amounts needed will be based on the concentrations required for inhibition of *H. pylori* cells in *in vitro* assays and the clearance

25   rates of the carbohydrates. The dosage is also dependent on whether one or more carbohydrates are administered. A synergistic effect may be seen with combinations of carbohydrates, other pharmaceuticals such as antibiotics, multivalent forms of the natural ligand or derivatives thereof, designed to increase affinity and/or avidity for *H. pylori*.

The present invention will be exemplified in the following, non-limiting

30   examples:

Examples

Experimental procedures

Bacterial Strains and Growth Conditions

H. pylori strain CCUG17875 and CCUG 17874 (Australian) were obtained from

5 CCUG, Göteborg, Sweden. Strain MO19 (US) and was described previously (T. Borén, P.

Falk, K. A. Roth, G. Larson, and S. Normark, *Science.* 262, 1892 (1993),). Strain 26695 was

recently genomically sequenced (J-F. Tomb et al., *Nature* 388, 539 (1997).). The molecular

construction and Lewis b antigen binding properties of the *babA2*-mutant was recently

described (D. Ilver, et al., *Science*, 279, 373 (1998)). The panel of 91 *H. pylori* fresh clinical

10 isolates came from the University Hospital in Uppsala, Sweden. Bacteria were grown at 37°C

in 10 % CO_2 and 5% O_2 (T. Borén, P. Falk, K. A. Roth, G. Larson, and S. Normark, *Science..*

262, 1892(1993), for 2 days for optimal Le b antigen binding activity.

Bacterial in situ adhesion and inhibition assay

15 Bacterial in situ adherence assay (Fig. 1 and Fig 2) was as described (P. Falk *et*

al., Proc. Natl. Acad. Sci. U.S.A., 90, 2035 (1993)). Human stomach samples were obtained

from the Department of Gastroenterology, Barnes-Jewish Hospital/Washington University, St.

Louis. Bacteria were labelled with fluorescein isothiocyanate (FITC), Sigma, St. Louis.

Bacterial suspensions were diluted to 0.15 OD_{600} in blocking buffer and 200μL was applied

20 to the sections, incubated for 1h at room temperature, and washed 6x5min (also described in

Falk, P., Borén, T., Haslam, D., Caparon M.G. (1994). Bacterial Adhesion and Tissue

Colonization Assays *Methods. Cell Biology*, 45, 165-192; Borén T., Wadström T., Normark

S., Gordon. J. I., and. Falk P. G. (1997) Methods for the Identification of *H. pylori* Host

Receptors. *Meth. Molecular Medicine,* 8, 205-224. The ability of glycoconjugates to inhibit

25 the bacterial adherence to human stomach in situ was analysed with Lewis b conjugates in

10μg/mL concentration, and the sialyl-Lewis conjugate used in 20μg/mL concentration.

Reduction in bacterial binding was estimated by counting the number of adherent bacteria

under 200X magnification (Fig. 7 A, B, C). Each value is the mean +- SEM of 10 different

fields. The control where bacteria were not pre-incubated with glycoconjugates was defined

30 as 100% binding.

Statistical Analysis of bacterial adherence in situ and inhibition experiments; A comparison

between the two different bacterial strains (CCUG 17875 and double mutant (DM)) and

control was performed with the Wilcoxon/Student T-test non-parametric test. P values below 0,05 were considered significant. Value £ 0,001(***); Value £ 0,01 (**); Value < 0,05 (*)

Preparation, purification and identification of glycosphingolipid receptors

5   Glycosphingolipids were isolated and characterized by mass spectrometry, ^{1}H NMR, and degradation studies, as described (Karlsson, K.-A. (1987). Preparation of total non-acid glycolipids for overlay analysis of receptors for bacteria and viruses and for other studies. Methods Enzymol. *138*, 212-220. A *H. pylori*-binding glycosphingolipid was isolated from human gall bladder adenocarcinoma by repeated chromatography on silicic acid columns of 10   the native glycosphingolipid fractions, or acetylated derivatives thereof. Mild acid hydrolysis was done by incubating the glycosphingolipids in 1% (v/v) acetic acid for 1 hr at 100°C.

      Negative ion FAB mass spectra were recorded on a JEOL SX-102A mass spectrometer (JEOL, Tokyo, Japan). The ions were produced by 6 keV xenon atom bombardment, using triethanolamine as matrix and an accelerating voltage of -10 kV.

15

Analyzes of *H. pylori* binding to separated glycosphingolipids

      Culture and ^{35}S-labelling of *H. pylori* was as outlined in (Ångström, J., Teneberg, S., Abul Milh, M,. Larsson, T., Leonardsson, I., Olsson, B.-M., Ölwegård Halvarsson, M., Danielsson, D., and Karlsson, K.-A. (1998). The lactosylceramide binding specificity of 20   *Helicobacter pylori*. Glycobiology *8*, 297-309.). Mixtures of glycosphingolipids (20-40 μg/lane) or pure compounds (0.002-4 μg/lane) were separated on aluminium-backed silica gel 60 HPTLC plates (Merck), using chloroform:methanol:water 60:35:8 (v/v/v) as solvent system. Chemical detection was done with anisaldehyde (Waldi, D. (1962) Sprühreagentien für die dünnschicht-chromatographie. In Dünnschicht-Chromatographie, E. Stahl ed. (Berlin: 25   Springer-Verlag) pp. 496-51).

      Binding of radiolabelled *H. pylori* to glycosphingolipids on thin-layer chromatograms was performed as described above (Ångström et al., 1998) using suspensions of bacteria diluted in phosphate-buffered saline (PBS), pH 7.3, to 1x10^8 CFU/ml. The specific activities of the suspensions were approximately 1 CPM per 100 *H. pylori* organisms. Binding 30   of monoclonal antibodies was done as described (Magnani, J.L., Brockhaus, M., Smith, D.F., Ginsburg, V., Blaszczyk, M., Mitchell, K.F., Steplewski, Z., and Koprowski, H. (1981). A monosialoganglioside is a monoclonal antibody-defined antigen of colon-carcinoma. Science *212*, 55-56). Anti-sialyl-Lewis x monoclonal antibodies (clone KM-93) were from Seikagaku

Corp., Tokyo, Japan and anti-sialyl-Lewis a monoclonal antibodies (CA 19-9) from Signet Laboratories, Inc., Dedham, MA 02026, USA.

Radio Immuno Analyses with Neoglycoconjugate Receptors

5   The sialyl-alfa2.3lactose-, sialyl-alfa2.6lactose-, sialyl-Lewis a-, and Lewis b-oligosaccharide antigens used for neoglycoconjugate preparations were purified by HPLC, structurally identified and characterized with NMR-spectroscopy, and more than 95% pure. These conjugates were attached to albumin with an APD (acetylphenylenediamine) spacer attached to the carbohydrate by reductive animation and thus the terminal reducing
10   monosaccharide unit of the oligosaccharide is reduced and is present as an aminoalditol, IsoSep AB, Tullinge, Sweden (T. Borén, P. Falk, K. A. Roth, G. Larson, and S. Normark, *Science.* **262**, 1892 (1993), P. D. Rye, *Nature Biotechnology* 2, 155 (1996)). The synthesised sialyl-Lewis x- tetrasaccharide antigen was conjugated to albumin with the MPE (mercaptopropionyl-amidoethyl) -spacer, IsoSep AB. Synthesised sialyl-Lewis x-
15   tetrasaccharide and sialyl-acetyllactosaminee, both with a either a 3 carbon or 14 carbon (extended/hydrophilic) spacer, conjugated to albumin, were obtained from Dextra Laboratories, Reading, UK. The RIA (Fig. 4) was performed according to (P. Falk, T. Borén, D. Haslam, M. G. Caparon, *Meth. Cell Biol.* **45**, 161 (1994)) with minor modifications; the glycoconjugates were ^{125}I-labelled by the Chloramine T method. 1 ml of bacteria ($A_{600}=$
20   OD 0.10) was incubated with 400 ng of ^{125}I-labelled conjugate (that is an excess of receptor substrate) for 30 min. in phosphate buffered saline (PBS), 0.5 % albumin, 0.05 % Tween-20 (BB-buffer). After centrifugation, the ^{125}I-activity bound to the bacterial pellet was measured by gamma scintillation counting. Binding experiments were reproducible and performed in triplets. In addition, the level of binding-activity within the strain was stabile.

25

Construction of the bab-mutants

To make the *babA* deletions, *babA* including the *baba2* upstream sequence was amplified by the F2 (forward) and R39 (reverse) primers and cloned in pBluescript SK (Stratagene, La Jolla). The vector was linearised withR41 and F38. The camR gene (Y. Wang
30   and D. E. Taylor, *Gene* **94**, 23 (1990)) was ligated between the fragments, and strainCCUG17875 was transformed with selection for CamR. The *H. pylori* transformants were analyzed for binding to^{125}I-labelled Le b glycoconjugate and the location of the camR gene, and thus the copy mutated, was analyzed by PCR with the upstream primers F2 (*babA2*)

or F44 (*babA1*) in combination with primer R11.

By introduction of the inactivated babA1-allele into the *babA2*-mutant, the *babA1A2*-double mutant was constructed. In order to select for both inactivated alleles, a second resistance marker KanR was introduced into the second babA-allele.

5 The used primers had the following sequences:

F2:CTTAAATATCTCCCTATCCC; R39: CAAATACACGCTATAGAGCC;

R41: GCGAGCCTAAAGTTAATGA; F38: ACGTGGCGAACTTCCAATTC;

F44: CAGTCAAGCCCAAAGCTATGC; R11: CGATTTGATAGCCTACGCTTGTG

10 *H. pylori* **adherence to immobilized neoglycoconjugates in ELISA (Fig. 6)**

Sialyl-Lewis a-PAA, sialyl-Lewis x-PAA, 3'-HSO3-Lewis a-PAA, and 3'-HSO3-Lewis x-PAA, i.e. synthesised sialylated or sulphated Lewis antigens conjugated to polyacrylamide backbone were obtained from Syntesome GmbH, Munchen, Germany. The conjugates were added in dilution series of 1 μg, 100ng, and 10 ng, in 90μl 1% BSA PBS

15 0.05% Tween, to streptavidin coated microtiter (ELISA) plates (Roche Diagnostics Scandinavia AB, Bromma, Sweden). After one hour of incubation in room temperature, the plate was blocked over night at 4°C, with 500ng biotinylated albumin in 300μl 1% BSA PBS 0.005% Tween. CCUG 17875 and the *babA1A$_2$* double mutant were harvested after 43 hours incubation on blood agar plates (see Bacterial Strains and Growth Conditions), washed once

20 in 1% BSA in PBS 0.05% Tween, and then resuspended in 1% BSA in PBS 0.05% Tween. A final OD$_{600}$ was set to 0.5/ ml ($5*10^6$ CFU/ ml). 150 μl bacteria was added to each well. Plates were incubated for 1 hour in room temperature and then washed three times in 300μl PBS 0.05% Tween. Adherent bacteria were detected by polyclonal rabbit antisera at a dilution of 1:3000, raised against formalin fixed bacteria of strain CCUG 17875 in New Zealand rabbits

25 (Agrisera AB, Vännäsby, Sweden) The antibodies were allowed to incubate in 1% BSA in PBS 0.05% Tween for 30 minutes at room temperature. 150 μl of the suspension was added to the wells for 1 hour at room temperature The same procedure were performed for the secondary anti rabbit antibody conjugated to HRP (DAKO, Goat anti rabbit immunogloubulins-HRP) at a dilution of 1:1000 after three washes in 300μl PBS 0.05%

30 Tween. After three final washes in 300μl PBS 0.05% Tween, 100 μl peroxidase substrate (3.5 mM H$_2$O$_2$ and 2.2 mM *o*-phenylene diamine hydrochloride in 0.05 M sodium citrate phosphatase buffer, pH 5.0) was added. After 5 minutes the reaction was stopped by adding

25 μl 4 M H$_2$SO$_4$. The products of the horseradish peroxidase reaction were quantified in a microtiter plate reader at 490 nm.

Antibody inhibitions of bacterial binding *in situ*.

H. pylori CCUG 17875 and the *babA1A2*- -mutant were overlaid on tissue sections pre-treated with monoclonal antibodies and analyzed by *in situ* adherence. Gastric tissue sections were pre-incubated with anti-Lewis b monoclonal antibodies, Immucor, Inc. Norcross, GA or anti-sialyl-Lewis x monoclonal antibodies (clone KM-93), Seikagaku Corp., Tokyo, Japan, in a dilution of 1:100x for one hour. *H. pylori* was with an ODA600=0,2 was overlaid as described in (described (P. Falk *et al., Proc. Natl. Acad. Sci. U.S.A.*, **90**, 2035 (1993)). Excess bacterial cells were removed by 6x5 min washings in (BB)-blocking buffer. . Reduction in bacterial binding was estimated by counting the number of adherent bacteria under 200X magnification (Fig. 8). Each value is the mean +- SEM of 10 different fields. The control where bacteria were not pre-incubated with glycoconjugates was defined as 100% binding. Statistical Analysis of bacterial adherence in situ and inhibition experiments; A comparison between the two different bacterial strains (CCUG17875 and *babA1A2*-double mutant (DM)) and control was performed with the Wilcoxon/Student T-test non-parametric test. P values below 0,05 were considered significant.

Value £ 0,001 (***); Value £ 0,01 (**); Value < 0,05 (*)

Results

1. The *H. pylori* babA-mutant adheres to the gastric tissue independent of the Lewis b antigen

babA-mutants in strain CCUG 17875 had previously been made by inactivation of the babA1 allele, without phenotypic effect, or by inactivation of the *babA2* allele, with concomitant loss of the Lewis b antigen binding properties. The latter results supported the results of the BabA-protein as the Lewis b antigen binding adhesin (D. Ilver et al., *Science* 279, 373 (1998)). In the present series of experiments, the *babA2* mutant was analyzed for binding properties by the *in situ* adherence assay. The binding activity in situ was found to be close to 50% compared to the CCUG 17875 wild-type strain (by the number of adherent bacterial cells),and the binding pattern of the mutant looks most similar to the binding pattern of the *H. pylori* CCUG 17875 wild-type (wt) bacteria (data not shown). Since recombination in between babA alleles could possible have moved the silent babA1 allele into thebabA2-allele, (by replacement of the CamR cassette), a *babA1/babA2*-(a KanR/CamR)-mutant was

constructed, where both babA-alleles were inactivated by recombination. However, the binding activity *in situ* by the *babA1/babA2*-mutant was still found to be close to 50% compared to the CCUG 17875 wild-type strain (Fig. 7A, by the number of adherent bacterial cells) and the binding pattern of the *babA1/babA2*-mutant looks most similar to the binding

5 pattern of the *H. pylori* CCUG 17875 wild-type (wt) bacteria (Fig. 1 B, C). Binding to the surface mucus cells was previously shown to be mediated by the fucosylated histo-blood group antigens, such as the Lewis b antigen (T. Borén et al. *Science 1993,* 262, 1892). Pre-incubation of the *H. pylori* wt-strain with low concentrations (10µg/mL) of soluble Lewis b antigen (IsoSep AB, Tullinge, Sweden) results in an almost total inhibition (80% reduction) in

10 binding (Fig. 1E and Fig. 7A). In contrast, binding by the *babA1/babA2*-mutant to the surface mucus cells was not possible to inhibit by soluble Lewis b antigen (Fig. 1D), suggesting that the *ba babA1/babA2*-mutant strain has induced the expression of a complementary binding/adhesive property, and subsequent recognition of a distinctly different receptor.

15 **2. Adherence of the *H. pylori* babA1/babA2-mutant is dependent on expression of alfa1,3/4 fucosyl transferase in the gastric mucosa**

Adherence experiments *in situ* by *H. pylori* wild type and the *babA1/babA2*-mutant were also performed using histo-tissue sections of mouse (FVB/N) and, in addition, the transgenic "Lewis b mouse" gastric mucosa. The "Lewis b mouse" express the alfa 1,3/4

20 fucosyl transferase (alfa1,3/4 FT) in the mouse gastric mucosa, resulting in the expression of the (otherwise) human specific Lewis b antigen in the pit and surface mucus cells (P.G. Falk et al., (1995) *PNAS,* 92, 1515). In analogy with previous data (P.G. Falk et al, (1995) *PNAS,* 92, 1515). the *H. pylori* wt-bacteria bind poorly to normal mouse gastric mucosa *in situ*, while binding is efficient to the "Lewis b mouse" gastric mucosa, i.e. to the surface mucus cells (**Fig**

25 **2 C, E**). The new results demonstrate that the *babA1/babA2*-mutant bacteria behave very similar, i.e. there is an efficient binding activity induced by the healthy "Lewis b mouse" gastric mucosa i.e. to the surface mucus cells (Fig. 2 D). In contrast, binding by the *babA1/babA2*-mutant to non-transgenic mouse is poor and limited to the most upper layer, most likely to the mucins in the protective mucus (**Fig 2 B**). These results suggest that the

30 receptor utilised by the *babA1/babA2*-mutant is dependent of the additional alfa-1.3/4-fucose residue, added by the power of the human-specific fucosyl-transferase activity of the "Lewis b mouse".

3. The *babA1/babA2*-mutant dem nstrate affinity f r human specific sialylated glycosphingolipids, i.e., for gangliosides

Screening of potential receptor structures unique for the*babA1/babA2*-mutant was performed by adherence experiments to well-defined panels of MS-characterized
5   glycolipids, from defined and unique sources and tissues. Binding of *H. pylori* and monoclonal antibodies to glycosphingo-lipids was evaluated using the thin-layer chromatogram binding assay (J. Ångström *et al.*, *Glycobiology* **8**, 297 (1998); J. M. McKibbin *et al.*, *J. Biol. Chem.* **257**,755 (1982)), i.e., glyco-lipids were separated on HPTLC-plates, and *H. pylori* CCUG 17875 wild type bacteria and the *babA1/babA2*-mutant were
10   overlaid on the plates and binding of radio labelled bacterial cells was detected. (See Experimental procedures). Four *H. pylori* strains were tested; CCUG 17874 which binds to glycosphingolipids in a sialic acid-dependent manner, but does not recognize the Le^b epitope (D. Ilver et al., Science 279, 373 (1998); Miller-Podraza, H., Abul Milh, M., Teneberg, S., and Karlsson, K.-A. (1997) Binding of *Helicobacter pylori* to sialic acid-containing
15   glycolipids of various origins separated on thin-layer chromatograms. Infect. Immun. *65*, 2480- 2482), the Lewis b-binding strain CCUG 17875, which is devoid of sialic acid binding capacity (Ilver et al., 1998; Miller-Podraza et al., 1997), the *babA2*-mutant and the *babA1A2*-mutant. The results from Fig. 3 are summarised in Table 1.

The *babA2* mutant and the *babA1A2* mutant differed from the parent strain
20   CCUG 17875 in two respects. Unlike the 17875 strain, the *babA2* mutant and the *babA1A2* mutant did not recognize the Lewis b-6 glycosphingolipid (Fig. 3E, lane 9), i.e. the expected behaviour of the *babA*-mutants. Instead, another binding capacity has emerged, manifested by the binding of these mutant strains to slow-migrating acid glycosphingolipids of human neutrophil granulocytes and human gall bladder adenocarcinoma (Fig. 3E, lanes 2 and 4) in a
25   manner that was indistinguishable from the binding pattern obtained with strain CCUG 17874. The binding of the *babA2* mutant, the *babA1A2* mutant, and CCUG 17874 was abrogated by the removal of sialic acid by mild acid hydrolysis (See Experimental protocol) (Fig. 3, lanes 3 and 5), demonstrating the involvement of sialylated structures in the binding process. However, no binding to the ganglio-series gangliosides of calf brain was obtained
30   (lane 1, and Table 1, Nos. 1-4), suggesting the involvement of additional structures for a full receptor epitope, since the presence of sialic acid *per se* was not enough to support bacterial binding.

In conclusion, specific binding by the *babA1A2* mutant was restricted to sialylated (acidic) glycolipids from human sources, such as from granulocytes. In contrast,

there was no binding by the *H. pylori* wt-strain, and, in addition, no binding by the *babA1A2*
mutant was detected after de-sialylation, or to sialylated glycolipids from non-human sources.

The gangliosides of human neutrophil granulocytes have been thoroughly
characterized (Fukuda, M.N., Dell, A., Oates, J.E., Wu, P., Klock, J. C., and Fukuda, M.

5   (1985). Structures of glycosphingolipids isolated from human granulocytes. J. Biol. Chem.
260, 1067-1082; Stroud, M.R., Handa, K., Salyan, M.E.K., Ito, K., Levery, S.B., Hakomori,
S.-i., Reinhold, B.B., and Reinhold, V.N. (1996a). Monosialogangliosides of human
myelogenous leukemia HL60 cells and normal human leukocytes. 1. Separation of E-selectin
binding from non-binding gangliosides, and absence of sialosyl-Lewis x having tetraosyl to

10   octaosyl core. Biochemistry *35*, 758-769; Stroud, M.R., Handa, K., Salyan, M.E.K., Ito, K.,
Levery, S.B., Hakomori, S.-i., Reinhold, B.B., and Reinhold, V.N. (1996b).
Monosialogangliosides of human myelogenous leukemia HL60 cells and normal human
leukocytes. 2. Characterisation of E-selectin binding fractions, and structural requirements for
physiological binding to E-selectin. Biochemistry *35*, 770-778; Müthing, J., Spanbroek, R.,

15   Peter-Katalinic, J., Hanisch, F.-G., Hanski, C., Hasegawa, A., Unland, F., Lehmann, J.,
Tschesche, H., and Egge, H. (1996). Isolation and structural characterisation of fucosylated
gangliosides with linear poly-N-acetyllactosamineyl chains from human granulocytes.
Glycobiology *6*, 147-156). The main components are the GM3 ganglioside and
sialylneolactotetraosylceramide. The larger gangliosides are based on repetitive *N*-

20   acetyllactosaminee units, and in many cases carry Fuc(alfa)-residues linked to the 3-position
of GlcNAc. In addition, NeuAc may be alfa3- or alfa6- linked to the terminal Gal of neolacto-
tetraosylceramide and the longer glycosphingolipids with repetitive *N*-acetyllactosaminee
units. Gangliosides with repetitive *N*-actyllactosaminee core substituted with fucose residues
have also been described in human adenocarcinomas (Hakomori, S.-i. (1989) General concept

25   of tumour-associated carbohydrate antigens: their chemical, physical and enzymatic basis. In
Gangliosides and Cancer, H.F. Oettgen, ed. (New York: VCH Publishers) pp. 57-68).

The results from the *in situ* adherence- and inhibition- experiments, in
combination with the HPTLC bacterial overlay assay, suggest the *babA1A2* mutant receptor to
be sialylated, and in addition, dependent on alfa-1.3/4-fucose residue(s), i.e. much similar to

30   the well-known selectin-receptors and tumour markers, the sialyl-Lewis x and sialyl-Lewis a-
antigens (J. Sakamoto *et al.*, *Cancer Res.*, **49**, 745 (1989)., Takada *et al.*, *Cancer Res.*, **53**, 354
(1993), Amado *et al.*, *Gastroenterology*, 114, 462, 1998). However, in the HPTLC overlay
experiments, almost no binding was detected to purified sialyl-Lewis a glycolipid.

4. The receptor specificity, affinity and prevalence of *H. pylori* for sialylated receptors

The detailed receptor specificity was analyzed by binding experiments to radio labelled semi-synthetic glycoproteins (i.e. neo-glyco-conjugates).These were either made from natural/purified or synthesised sialylated oligosaccharides conjugated to human serum albumin (**Fig. 4**). Interestingly, the binding experiments demonstrated a high binding capacity to sialyl-Lewis X for both the *BabA2* mutant, the *babA1A2* mutant and by the *H. pylori* CCUG 17875 and CCUG 17874 wild-type bacteria. Binding by the wild-type is reproducible approx. 30% reduced, compared to the mutant (Fig. 4), suggesting either a down regulation in expression of the corresponding adhesin or sterical hindrance in presentation or binding activity. In addition, alfa2.3lactoseamine with a 14 carbon spacer linked to the albumin core demonstrated rather efficient binding, while the equivalent structure linked by a shorter, 3 carbon spacer, is much reduced in binding, The improved binding by the longer spacer, suggest the importance of steric flexibility in correct receptor presentation for optimal interaction with the bacterial adhesin. Poor binding was also demonstrated by the related sialyl-alfa2.3lactose-, sialyl-alfa2.6lactose-, and sialyl-Lewis a- antigens.

Nevertheless, the terminal alfa 2.3 linked sialic acid residue is crucial for receptor activity. Binding experiments with the closely related Lewis y pentasacharide antigen did not detect any binding activity (Fig. 4), pointing to the involvement of the sialylated terminal for correct formation of the receptor epitope.

In Fig. 4 several combinations of adherence properties are exemplified. The CCUG 17875 strain is subsequently competent for interaction with both the soluble Lewis b antigen and the sialyl-Lewis x antigen, while the CCUG 17874 strain (another clinical wild-type isolate and, in addition, type strain), is restricted to sialyl-Lewis x antigen binding, i.e. similar to the *babA2* mutant and the *babA1A2* mutant. Interestingly, both the MO19 strain and the HP 26695 strain (genomically sequenced by the TIGR-institute) (J-F. Tomb et al., *Nature* **388**, 539 (1997)) are devoid of both binding properties.

The earlier determination of affinity, reported in SE 9901007-6 by the same inventors involved a sialyl-Lewis X antigen less suited for Scatchard affinity analyses. The present inventors have therefor, during the priority year, analyzed the affinities of the *babA1A2*-mutant for sialylated conjugates according to Scatchard (see Table 2) (Scatchard, A.G. (1949) The attractions of proteins for small molecules and ions. Ann. N.Y. Acad. Sci. *51*, 660-672.). The *babA1A2*-mutant demonstrated the high affinity of $1 \times 10^8 M^{-1}$ for the sialyl-Lewis x antigen. The repetitive sialyl-Lewis x antigen was synthesized and confer the high affinity of $2 \times 10^8 M^{-1}$. The oligosaccharide part of the repetitive sialyl-Lewis x antigen

conjugate was synthesized enzymatically from lactose, using the appropriate glycosyl

transferases and nucleotide sugars (M Bårström, M Bengtsson, O Blixt, and T Norberg: "New

lipophilic derivatives of reducing oligosaccharides and their use in enzymatic reactions:

efficient synthesis of sialyl lewis a and sialyl dimeric lewis x glycoconjugates", Submitted to

5   Carbohydrate Res., 2000).

Conjugation to Human Serum Albumin was carried out by the isothiocyanate

procedure (E Kallin, H Lönn, T. Norberg: "New derivatization and separation procedures for

reducing oligosaccharides", Glycoconjugate J. 3, (1986) 311-319). An average substitution

degree of 11 haptens/HSA molecule was obtained, according to MALDI-TOF mass

10   spectroscopy. In contrast, sialyl(alfa)2,3lactose, i.e., the equivalent core structure devoid of

fucose residues, demonstrate the 20-fold lower affinity of $1 \times 10^7 M^{-1}$. For the *babA1A2*-mutant,

close to 1000 binding sites for the sialyl-Lewis x conjugate was found, i.e. similar to the

number of binding sites for the Lewis b antigen receptor (Ilver, D., Arnqvist, A., Ögren, J.,

Frick, I.M., Kersulyte, D., Incecik, E.T., Berg, D.E., Covacci, A., Engstrand, L. and Boren, T.

15   (1998) *Helicobacter pylori* adhesin binding fucosylated histo-blood group antigens revealed

by retagging. Science *279*, 373-377.).

In order to investigate the importance of the sialic acid residue for the formation of the

bacterial binding site, the di-fucosylated Lewis y penta-saccharide antigen where the sialic

acid residue is replaced with an alfa1,2fucose residue (Table 3) (Behar, V. and Danishefsky,

20   S.J. (1994) A highly convergent synthesis of the Lewis y blood group determinant in

conjugatable form, Angew. Chem. Int. Ed. Engl. *33*, 1468-1470), and the sialyl-alfa 2,6

lactose conjugate were analyzed, but did not demonstrate any binding activity (data not

shown). The combined results point to the strict requirement for the alfa 2,3 linked sialic acid

residue as a critical component in formation of the sialyl-Lewis x type of receptor determinant

25   for *H. pylori* in combination with the repetitive Le x antigen.

The prevalence of sialyl-Lewis x antigen binding activity was assessed among

91 Swedish clinical *H. pylori* isolates and 44%, that is 40 isolates, bound the

neoglycoconjugate antigen. None of the reference strains (Fig. 4A), nor any of the 91 clinical

isolates, bound to the related Lewis y penta saccharide antigen (data not shown). These results

30   provide evidence for the prevalence of the new sialyl-based Lewis x receptor also in natural

clinical isolates. In addition, 14 out of 91 strains, i.e. 15%, demonstrate binding to the sialyl-

Lewis a antigen. Interactions with the sialyl-Lewis a antigen is extremely intriguing

considering sialyl-Lewis a as an established tumour antigen (especially in relation to *H. pylori*

as a possible carcinogen). In case of cell transformation, and emergence of tumour markers

such as sialyl-Lewis a, *H. pylori* might possibly have an additional receptors candidate available.

5. Preparation and identification of high affinity *H. pylori* ganglioside receptors

The interest of the present inventors was thus directed towards fucosylated neolactoseries gangliosides. Fucosylated sialylated lactosamine structures are created by expression of alfa1,3/(4) fucosyltransferase activities capable of modifying acceptors containing alfa(2,3) sialic acid-substituted lactosamineoglycans, such as Lewis x, Galß1.4(Fucalfa1.3)-GlcNAcß1-R (where R is a protein or other carbohydrate structure). The Lewis x antigen is a common trisaccharide structure, which forms the core of this sialylated structure, resulting in sialyl-Lewis x, i.e. NeuAcalfa2.3Ga.ß1.4(Fucalfa1)GlcNAc-R. Another possible structure would be difucosylated sialyl Lewis x, a longer polyfucosylated polylactosamineoglycan, or similar derivatives. The number of fucose-residues in the core chain might affect the affinity and aid in the stabilisation of the receptor-ligand complex/interaction. This interest was further increased by the finding that a binding pattern almost parallel to the pattern of strains CCUG 17874 and the mutant strains was obtained with monoclonal antibodies directed against sialyl-Lewis x (Fig 3, B). The optimal receptor could be of more complex type, as suggested by the slower migrating glycolipid bands that demonstrate high affinity receptor properties in the HPTLC-overlay analyses (Lanes 2 and 4).

A *H. pylori*-binding and anti-sialyl-Lewis x-reactive glycosphingolipid was isolated from the human gall bladder adenocarcinoma (Fig. 3, lane 6), and characterized by negative ion FAB mass spectrometry and ^{1}H NMR as NeuAcHex(Fuc)HexNAcHex-(Fuc)HexNAcHexHex with sphingosine and non-hydroxy 16:0 fatty acid (Fig. 5). Taken together with the anti-sialyl-Lewis x-binding activity a NeuAcα3Galβ4(Fucα3)GlcNAcβ3-Galβ4(Fucα3)GlcNAcβ3Galβ4Glcβ1Cer compound was suggested, *i.e.* a ganglioside with repetitive Lewis x core, previously described in human colonic adenocarcinoma (Fukushi, Y., Nudelman, E., Levery, S.B., Hakomori, S.-i., and Rauvala, H. (1984). Novel fucolipids accumulating in human adenocarcinoma. III. A hybridoma antibody (FH6) defining a human cancer-associated difucoganglioside (VI^{3}NeuAcV^{3}III^{3}Fuc$_2$nLc$_6$). J. Biol. Chem. *259*, 10511-10517). The binding-active compound was thus a ganglioside with repetitive Lewis x core (Fig. 5).

While almost no binding to sialyl-Lewis a hexaglycosylceramide (Fig. 3, lane 7) was obtained, a weak binding of the CCUG 17874 strain, the BabA2 mutant and the

BabA1A2 mutant to sialyl-Lewis x hexaglycosylceramide (lane 8) was occasionally observed. However, this binding required 2 nmol, while the detection level for NeuAcα3Galβ4(Fucα3)GlcNAcβ3-Galβ4(Fucα3)GlcNAcβ3Galβ4Glcβ1Cer was approximately 1 pmol.

5   The distinct difference in affinity argue for that the monomeric sialyl-Lewis x ganglioside exhibit features required for bacterial binding, while the dimeric or repetitive form is optimised in its presentation of the terminal sialic acid epitope.

At this stage an open question if the increased binding activity is dependent on the repetitive Lewis x element, or due to the longer carbohydrate chain giving optimal

10   exposure of the binding epitope, as has been described for monoclonal anti-sialyl-Lewis x antibodies (Müthing, J., Spanbroek, R., Peter-Katalinic, J., Hanisch, F.-G., Hanski, C., Hasegawa, A., Unland, F., Lehmann, J., Tschesche, H., and Egge, H. (1996). Isolation and structural characterisation of fucosylated gangliosides with linear poly-N-acetyllactosamineyl chains from human granulocytes. Glycobiology 6, 147-156).

15

6. The receptor specificity of *H. pylori* for sialylated receptors in ELISA

Since the *H. pylori* wild-type bacteria demonstrate binding to soluble sialyl-Lewis x antigen (Fig. 4), in contrast to the binding patterns as analyzed by the HPTLC binding assays (Fig. 3), there might be an intricate situation where the presence of the BabA-

20   adhesin, such as in the wild type strain, could sterically interfere with binding to the sialyl-Lewis x antigen in solid phase, i.e. to the cell surfaces *in vivo*.

An ELISA assay was constructed where bacterial binding was analysed to immobilised sialylated or sulphated Lewis x antigens. For these experiments, the Lewis b antigen was used as the control. Interestingly, the *babA1A2* mutant binds much more

25   efficiently to the immobilised sialylated receptor compared to the wild type strain, i.e. similar to the results gained from the HPTLC binding analyses. In contrast, binding by the wild type strain to the Lewis b antigen is most efficient, and subsequently completely lost in the *babA1A2* mutant. The drastic difference in binding results for soluble versus immobilized sialylated structures, is suggestive of a situation where interaction with sialylated mucin

30   molecules in the gastric mucus layer (lining the epithelial cells), might be compatible with the binding behaviour of the CCUG 17875 wild type, while tight interaction with cell surface immobilized or presented receptors might be confined to the *babA1A2* mutant. This would subsequently be a situation most similar to the binding pattern of strain CCUG 17874, where lack of the BabA-adhesin, by down regulation or phase shifting, in order to adapt to variations

in the local glycosylation patterns, and in efficient binding to sialylated receptors (Fig 3). In these analyses, a weak interaction with the sialyl-Lewis a antigen is also detected by strain CCUG 17875. However, the difference in binding is close to 100-fold lower compared to sialyl-Lewis x antigen. In addition, sulphated derivatives of the Lewis x/a antigens has been

5 demonstrated as efficient selectin-receptors (C.T. Yuen *et al.*, *J. Biol. Chem.*, 269, 1598, (1994); Brandley *et al.*, *Glycobiology*, 3, 663 (1993). 3'HSO3Lewis a- and 3'HSO3Lewis x - antigen conjugates were analyzed for bacterial binding in ELISA. However, no binding above background was detected suggesting a strict requirement for terminal alfa2.3 linked sialic acid in the receptor epitope, in contrast to the receptor /carbohydrate binding domains of the

10 selectin proteins (Fig. 6).

7. Adherence of the *H. pylori babA1/babA2*-mutant is inhibited by the sialyl-Lewis x antigen

In order to demonstrate that the receptor activity for the *babA1/babA2*-mutant

15 observed in the *in situ* adherence experiments by human gastric mucosa (Fig. 1 B, C) and, in addition, by the transgenic "Lewis b" mouse gastric mucosa (Fig. 2 D, E), is dependent on the sialyl-Lewis x antigen (Fig. 3, 4, 5, 6), the present inventors performed inhibition of adherence experiment *in situ*. Similar to the previous inhibition experiments with soluble Lewis B neoglyco-conjugates (Fig. 1, D, E), the inventors pre-incubated the *H. pylori* wild

20 type strain (CCUG 17875) and the *babA1/babA2*-mutant bacteria, with the sialyl-Lewis x conjugate, before analyses of bacterial binding *in situ* to both human gastric mucosa and to the "Lewis b" mouse gastric mucosa. Most interestingly, the inhibition experiments with sialyl-Lewis x almost completely prevented binding by babA-mutant bacteria (95% reduction), in both human (Fig. 1F and 7A) and "Lewis b" mouse (Fig. 2F and 7C) gastric

25 mucosa. In contrast, the sialyl-Lewis x inhibition experiments with the *H. pylori* wild-type bacteria to human gastric mucosa results in no reduction in binding (Fig. 1G and 7A).

However, a slight reduction in binding of approx. 35%, was observed with the *H. pylori* wild-type bacteria to the "Lewis b" mouse gastric mucosa (Fig. 2G and 7C). These experiments suggest that the mutant has functionally induced the binding properties of

30 an adhesin protein that is specific for sialyl-Lewis x antigens, i.e. yet another human specific antigen. The slight difference in binding pattern in between the human and transgenic tissues, suggest that the proportions of expressed Lewis b and sialyl-Lewis x antigens are rather different compared to human gastric mucosa. The humanised glycosylation pattern of the "Lewis b" mouse is driven by a truncated rat intestinal fatty acid binding gene promotor

(Fabpi) (P.G. Falk et al, (1995) *PNAS,* 92, 1515). In contrast, the glycosylation pattern of the human gastric mucosa/host is shaped and modulated by factors generated by the chronic inflammation process, such as cytokines and cell differentiation modulating signal molecules and, in addition, differences due to inflammation stimuli, such as cytokines, are most likely to

5 be expected.

8. Receptor epitopes for the *babA1/babA2*-mutant bacteria are recognised by a monoclonal antibody to the sialyl-Lewis x antigen.

The inhibition results with soluble receptor conjugates demonstrate that most of

10 the binding by the *babA1/babA2*-mutant is mediated by the sialyl-Lewis x antigen. However, the results from the HPTLC-binding analyses (Fig. 3) suggest that sialyl-Lewis x derivatives with higher molecular weight, possible of repetitive/dimeric nature are less well recognises by the monoclonal antibody. The present inventors have subsequently analyzed the effect on inhibition of bacterial adherence *in situ*, to human gastric mucosa, by monoclonal antibodies

15 to the sialyl-Lewis x, antigen and to the Lewis b antigen (**Fig. 8**). Pre-incubation of the tissue by the sialyl-Lewis x Mab results in a 40% reduction in binding by the*babA1/babA2*-mutant compared to no significant reduction in binding by the wild type strain (Fig. 8). In comparison, the Lewis b antigen MAb results in 78% reduction in binding by the wild type strain, while adherence of the *babA1/babA2*-mutant strain was unaffected. The 40 %

20 reduction in binding is convincingly efficient, yet suggest that the monoclonal sialyl-Lewis x antibody demonstrate a more restricted binding specificity compared to the*babA1/babA2*-mutant. These results are in analogy with the HPTLC-binding results (Fig. 3), where the dimeric sialyl-Lewis x glycolipid/antigen exhibit higher receptor affinity compared to the monomeric shorter carbohydrate structure.

25

9. Expression of the sialyl-Lewis x antigen and receptors for the *babA1/babA2*-mutant in gastric mucosa

The sialyl-Lewis x antigen seems to be a binding specificity utilised by normal clinical isolates and most likely highly complementary to the previously described Lewis b

30 antigen receptor. Both receptors arealfa-1.3/4-fucosylated and defined as human (primate) specific antigens. The unique alfa-1.3/4-fucosylation of *H. pylori* receptors, might subsequently explain *H. pylori* as a human (primate) specific pathogen. The difference in terminal substitution, in between these two groups of fucosylated blood group related antigens is extremely interesting, since it relates to distinct differences in the epithelial expression

patterns of glycosylation. However, the adult healthy human stomach is considered low in sialylated structures, and the presence of sialyl-Lewis x antigens as *H. pylori* receptors would not appear all that obvious. Nevertheless, increased sialylation levels are most often associated with conditions of inflammation and/or malignant transformation, i.e. cellular

5   states associated with the chronic *H. pylori* infectious process.

In order to investigate the possible relation in between gastric inflammation conditions and expression of *H. pylori* sialyl-Lewis x antigen receptors, the present inventors have screened gastric pinch-biopsies (i.e. very small biopsies) from 20 individuals. The present inventors found almost no sialyl-Lewis x dependent binding by the *babA1/babA2*-

10   mutant in 10 of the individual pinch-biopsies *in situ*, low and scattered binding in 7 of individuals, and good binding in biopsies of 3 individuals. However, these pinch-biopsies were obtained from routine screening of patients and almost all of these patients were without serious symptoms. One of the three high binding pinch-biopsies was chosen for the experiments in Fig. 1 and Fig. 7A. Six of the pinch-biopsies described above were evaluated

15   for "level of inflammatory cell infiltration". The (four) sections that confer low or modest binding of the *babA1/babA2*-mutant were found to be of "low inflammatory cell infiltration", as illustrated by the *in situ* adherence analyses of biopsy no. 9 (Fig. 7B), where binding by the *babA1/babA2*-mutant is much reduced. In contrast, the two biopsies that confer good binding by the *babA1/babA2*-mutant were of "moderate level of inflammatory cell infiltration". This is

20   in exemplified by biopsy no.12 (Fig 7A). These results suggest a correlation between binding by the *babA1/babA2*-mutant and the degree of inflammatory cell infiltration in the gastric tissue/level of inflammation response.

It is of course difficult, based on these results to define when or where the sialyl-Lewis x receptors will emerge, but the present inventors suggest that it might be during the

25   process of chronic atrophic gastritis, when simultaneously the mucus layer gets thinner and it might be beneficial for the bacteria to adhere more tightly to the cells, in order to avoid the acidic environment.

Based on the results, there might be the situation where *H. pylori* is targeted to the surface epithelial lining/gastric pit region, by adherence mediated by the Lewis b antigens.

30   During the chronic infection and inflammation process, the epithelial cells will response by up-regulation of the sialylation levels. This event/process then provides a second receptor level i.e. a consecutive or two-step mechanism for the microbial attachment process, and adhesion to the sialyl-Lewis x antigens, in the gastric pit region. A 2-step dependent mechanism for adhesion could be of great importance for the microbe, if initial targeting to

the surface mucus cells is mediated by the Lewis b antigens, followed by an intimate contact with the cellular membrane mediated by sialylated glycolipids.

A stepwise attachment mechanism might be extremely useful for the microbes, and could by triggering the infectious process induce a second level of cellular receptor expression, in order to promote adherence. Such mechanisms would direct them to a slightly shifted ecological niche during the chronic inflammation process, and subsequently driving the inflammation process further to development of acid peptic disease and/or malignant transformation. Another possible explanation might be to avoid initial interaction with sialylated inflammatory cells such as PMN-cells/granulocytes. Lectin mediated interaction with neutrophils has been demonstrated to activate oxidative bursts reactions (D. Danielsson, et al., *Scand-J-Gastroenterol*, 1994, 29, 2, 128-32). The receptor for such mechanisms has not been identified yet, but considering that human granulocytes are often used as model cells for sialyl-Lewis x antigen based selectin-interactions/adherence studies, there is a definite possibility that reactive interactions with granulocytes might be triggered by the interaction with sialyl-Lewis x antigen/receptor.

Much of the present experimental results and understanding has been made possible due to the bindings results generated by the *babA1A2*-"double"mutant (DM), previously defined by the inventors. Since the double-mutant is devoid of all Lewis b antigen binding properties, the specific binding by sialyl-Lewis x antigens in the gastric pit region could be demonstrated. The presence of the BabA adhesin (i.e. the wild-type) seems to somehow sterically interfere and prevent binding by the sialyl-Lewis x antigen *in situ*, as revealed by the present results of binding experiments in solid phase to sialylated receptors on HPLTC-plates and in ELISA.

The present inventors have demonstrated surprising sialyl-Lewis x antigen dependent binding modes, as a consequence of the gastric tissue inflammation response. Such signalling might be key-events for the *H. pylori* chronic infection cycle, supporting the chronic inflammation response and development of acid peptic disease/gastric cancer.

Although the invention has been described with regard to its preferred embodiments, which constitute the best mode presently known to the inventors, it should be understood that various changes and modifications as would be obvious to one having the ordinary skill in this art may be made without departing from the scope of the invention which is set forth in the claims appended hereto.

Table 1.

Table 1. Summary of results from binding of *Helicobacter pylori* to glycosphingolipids on thin-layer chromatograms

No.	Trivial name	Structure	17875[1]	17874[2]	Source
1.	Le^b-6	Fucα2Galβ3(Fucα4)GlcNAcβ3Galβ4Glcβ1Cer	+[3]	-	Human small intestine
2.	GM3	NeuAcα3Galβ4Glcβ1Cer	-	-	Calf brain
3.	GM1	Galβ3GalNAcβ4(NeuAcα3)Galβ4Glcβ1Cer	-	-	Calf brain
4.	GD1a	NeuAcα3Galβ3GalNAcβ4(NeuAcα3)Galβ4Glcβ1Cer	-	-	Calf brain
5.	GD1b	Galβ3GalNAcβ4(NeuAcα8NeuAcα3)Galβ4Glcβ1Cer	-	-	Calf brain
6.	S-Le^a	NeuAcα3Galβ3(Fucα4)GlcNAcβ3Galβ4Glcβ1Cer	-	-	Human gall bladder carcinoma
7.	S-Le^x	NeuAcα3Galβ4(Fucα3)GlcNAcβ3Galβ4Glcβ1Cer	-	(+)	Synthetic[4]
8.		NeuAcα3Galβ4Fucα3GlcNAcβ3Galβ4(Fucα3)GlcNAcβ3Galβ4Glcβ1Cer	-	+++	Human gall bladder carcinoma

1. Binding obtained with strain CCUG 17875.
2. Binding obtained with strain CCUG 17874, the BabA2 mutant and the BabA1A2 mutant.
3. Binding is defined as follows: +++ denotes a significant darkening on the autoradiogram when 1 pmol was applied on the thin-layer plate, + denotes a darkening at 2 nmol, (+) an occasional darkening at 2 nmol, while - denotes no darkening even at 2 nmol.
4. Obtained from Symbicom Ltd., Sweden.

Table 2.   Summary of results from binding of *Helicobacter pylori* to glycosphingolipids on thin-layer chromatograms

No.	Name	Description	1	2	Source
1.	Lewis b	Fucα2Galβ3GlcNAcβ3Galβ4Glcβ1Cer 4 Fucα1	+3	-	Human small intestine
2.	GM3	NeuAcα3Galβ4Glcβ1Cer	-	-	Calf brain
3.	GM1	Galβ3GalNAcβ4Galβ4Glcβ1Cer 3 NeuAcα2	-	-	Calf brain
4.	GD1a	NeuAcα3Galβ3GalNAcβ4Galβ4Glcβ1Cer 3 NeuAcα2	-	-	Calf brain
5.	GD1b	Galβ3GalNAcβ4Galβ4Glcβ1Cer 3 NeuAcα8NeuAcα2	-	-	Calf brain
6.	sialyl-Lewis a	NeuAcα3Galβ3GlcNAcβ3Galβ4Glcβ1Cer 4 Fucα1	-	-	Human gall bladder carcinoma
7.	sialyl-Lewis x	NeuAcα3Galβ4GlcNAcβ3Galβ4Glcβ1Cer 3 Fucα1	-	(+)	Synthetic from Symbicom Ltd.
8.	repetitive s-Lewis x	NeuAcα3Galβ4GlcNAcβ3Galβ4GlcNAcβ3Galβ4Glcβ1Cer 3 3 Fucα1 Fucα1	-	+3	Human gall bladder carcinom

1. Binding obtained with strain CCUG 17875. 2. Binding obtained with strain CCUG 17874, the *babA2* mutant and the *babA1A2* mutant. Binding is defined as follows: +3 denotes a significant darkening on the autoradiogram when 1 pmol of structure was applied on the thin-layer plate; + denotes a darkening at 2 nmol; (+) an occasional darkening at 2 nmol; while – denotes no darkening even at 2 nmol.

27

Table 3.   Glycoconjugates used in this study

No.	Name	Description
1.	Lewis a	Galβ3GlcNAcβ3Galβ4Glc 4 **Fuc**α1
2.	3′-sulfate-Lewis a	**HSO₃**-3Galβ3GlcNAcβ3Galβ4Glc 4 **Fuc**α1
3.	Lewis x	Galβ4GlcNAcβ3Galβ4Glc 3 **Fuc**α1
4.	3′-sulfate-Lewis x	**HSO₃**-3Galβ4GlcNAcβ3Galβ4Glc 3 **Fuc**α1
5.	Lewis y	Fucα2Galβ4GlcNAcβ3Gal 3 **Fuc**α1
6.	3′-sialyllactose	**Neu5Ac**α3Galβ4Glc
7.	6′-sialyllactose	**Neu5Ac**α6Galβ4Glc
8.	3′-sialyl-*N*-acetyllactosamine	**Neu5Ac**α3Galβ4GlcNAc
9.	VIM-2	**NeuAc**α3Galβ4GlcNAcβ3Galβ4GlcNAcβ3Galβ4Glcβ1Cer 3 **Fuc**α1

Claims

1. Use of fucosylated sialylated N-acetyl lactosamine structures and/or sialyl-Lewis antigen carbohydrate structure for the preparation of a pharmaceutical composition for
5   the treatment or prophylaxis in humans of conditions involving infection by *Helicobacter pylori* and related pathogens of the human gastrointestinal mucosa.

2. Use according to claim 1, in which the sialyl-Lewis antigen carbohydrate structure is capable of binding to adhesins present on the surface of *H. pylori*.

3. Use according to claim 1 or 2, in which the sialyl-Lewis antigen carbohydrate
10   structure is capable of inhibiting or substantially reducing the adhesion of *H. pylori* to epithelial cells of a histological section of human gastrointestinal mucosa.

4. Use according to any one of claims 1 – 3, in which the sialyl-Lewis antigen is chosen among sialyl-Lewis x and sialyl-Lewis a.

5. Use according to any one of claims 1 – 3, in which the sialyl-Lewis antigen is
15   chosen among dimeric or repetitive sialyl-Lewis x and dimeric or repetitive sialyl-Lewis a.

6. Use according to any one of claims 1 – 5, in which the conditions involving gastrointestinal infection by *H. pylori* comprise gastritis, chronic active gastritis, gastric ulcers, duodenal ulcers, gastric adenocarcinoma, and gastric lymphoma.

7. Use according to any of the claims 1-6, in which the sialyl-Lewis antigen
20   carbohydrate structure is bound to an inert substrate, preferably for long term release in the gastrointestinal tract.

8. Method for treating and/or preventing diseases in humans caused by infection by *H. pylori* of human gastric mucosa, said method comprising administering to a human patient in need thereof an effective amount of a fucosylated N-acetyl lactosamine
25   carbohydrate structure, such as a sialyl-Lewis antigen carbohydrate structure.

9. A method according to claim 8, in which the sialyl-Lewis antigen carbohydrate structure is capable of binding to adhesins present on the surface of *H. pylori*.

10. A method according to claim 8 or 9, in which the sialyl-Lewis antigen carbohydrate structure is capable of inhibiting or substantially reducing the adhesion of *H.*
30   *pylori* to epithelial cells of a histological section of human gastric mucosa.

11. A method according to any one of claims 8 – 10, in which the sialyl-Lewis antigen is chosen among sialyl-Lewis x and sialyl-Lewis a.

12. A method according to any one of claims 8 – 10, in which the sialyl-Lewis antigen is chosen among dimeric or repetitive sialyl-Lewis x and dimeric or repetitive sialyl-Lewis a.

13. Use of antibodies to a fucosylated sialylated N-acetyl lactosamine structure and/or sialyl-Lewis x carbohydrate structure for inhibiting the adherence of *H. pylori*.

14. Method for treating and/or preventing diseases in humans caused by infection by *H. pylori* of human gastric mucosa, said method comprising administering to a human patient in need thereof an effective amount of antibodies to a fucosylated sialylated N-acetyl lactosamine structure, such as a sialyl-Lewis x carbohydrate structure.

A   Human gastric mucosa in H/E
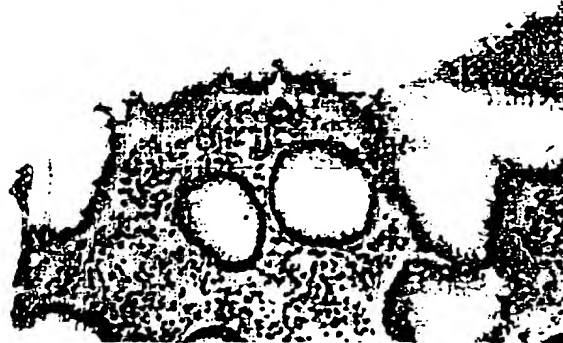
Fig. 1

babA₁A₂-mutant   CCUG17875 (wildtype)
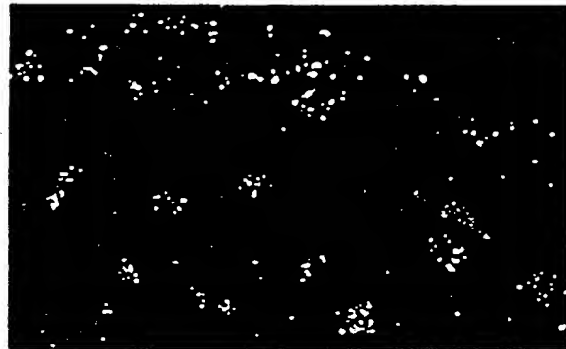
Binding to human gastric mucosa

B   *C*

Inhibition of binding by the Lewis b antigen

D   *E*
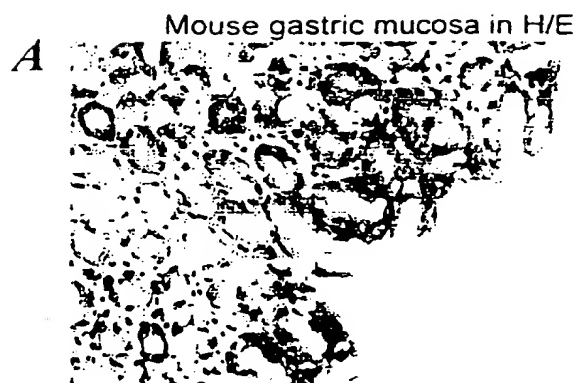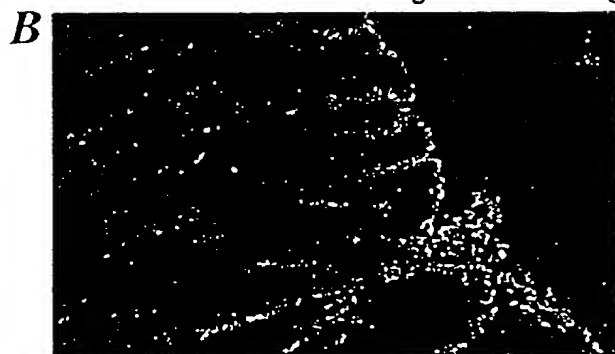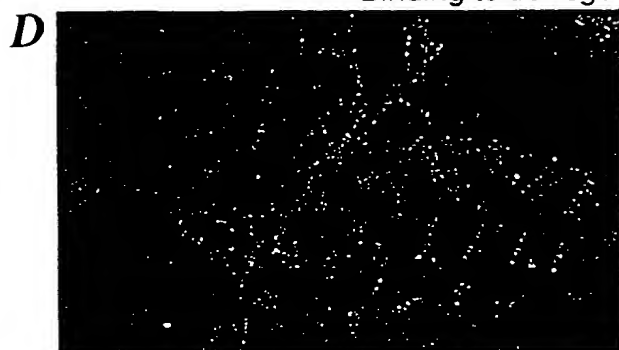
Inhibition of binding by the sialyl-Lewis x antigen

F   *G*

Mouse gastric mucosa in H/E

A

Fig. 2

babA1A2-mutant   CCUG17875 (wildtype)

Binding to non-transgenic mouse gastric mucosa

B   *C*

Binding to transgenic mouse gastric mucosa

D   *E*

Inhibition of binding to transgenic mouse gastric mucosa by the sialyl-Lewis x antigen
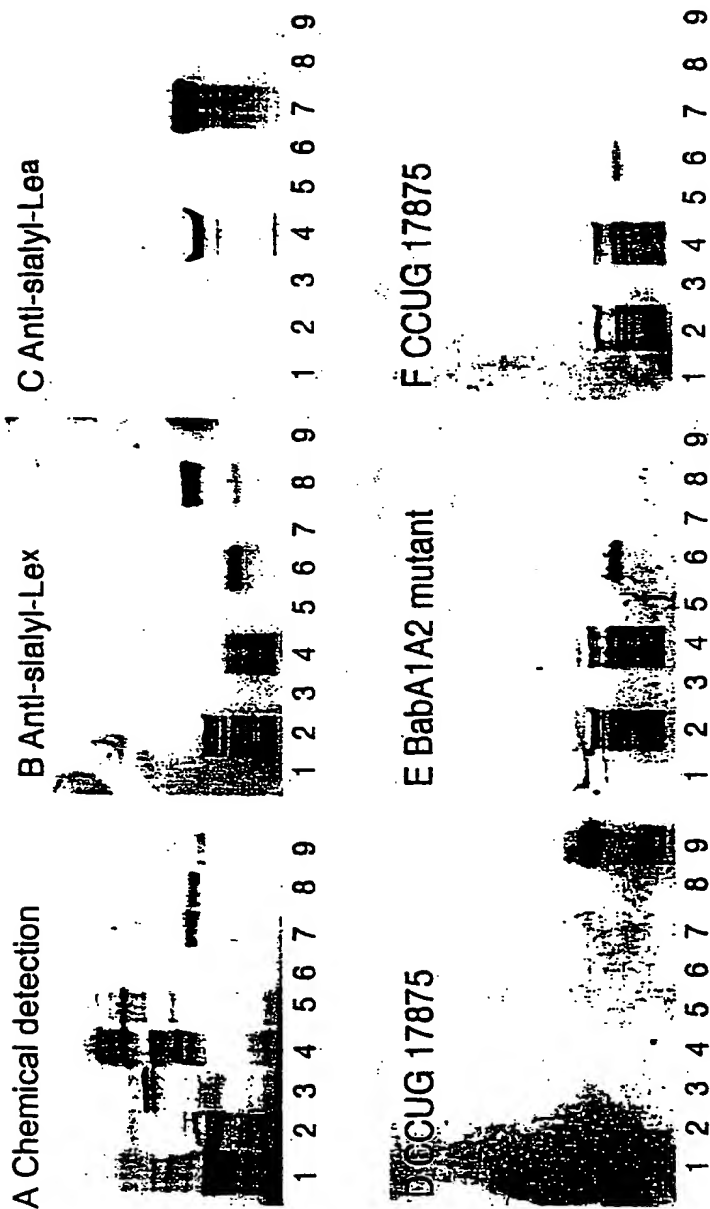
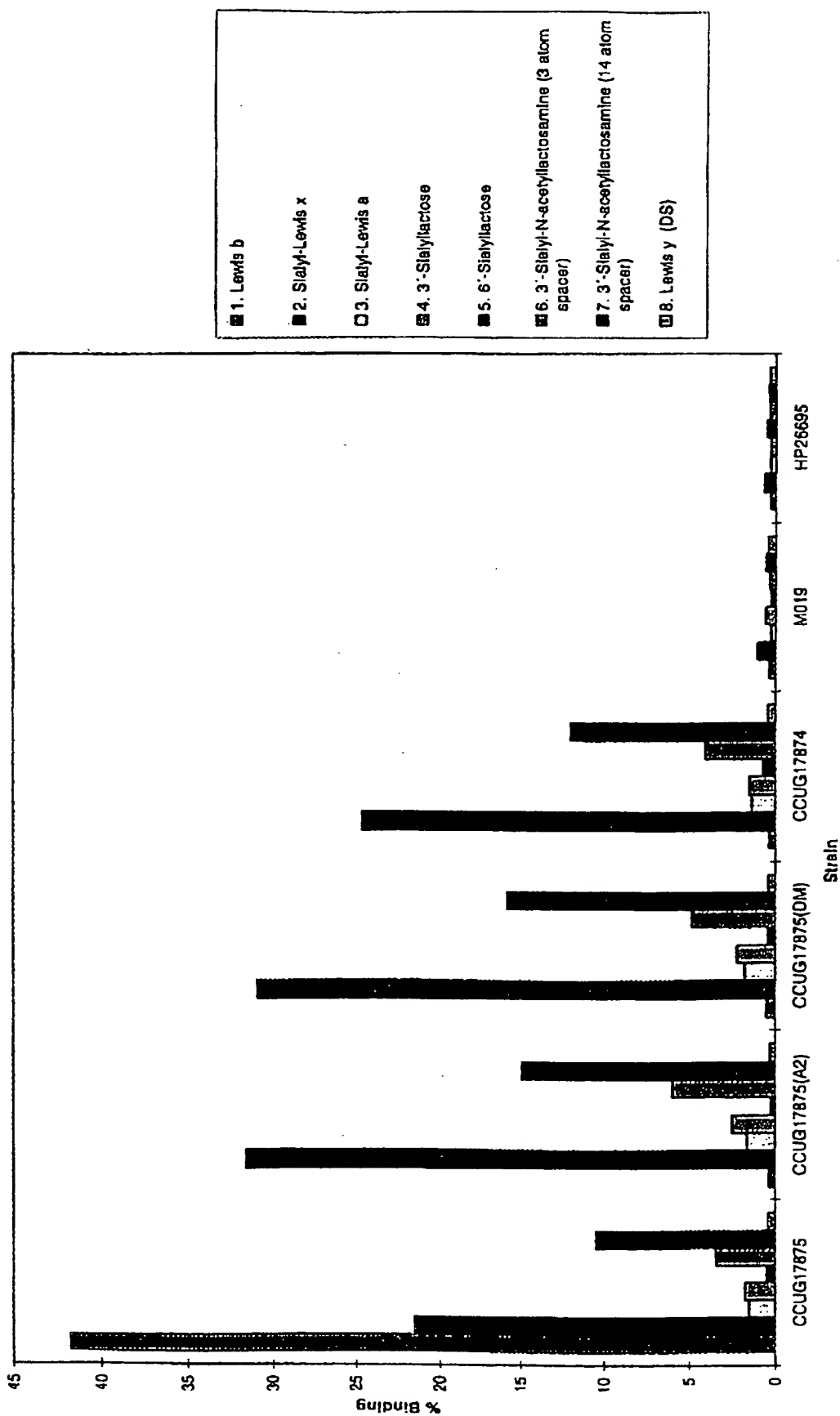*F*   *G*

Fig. 3

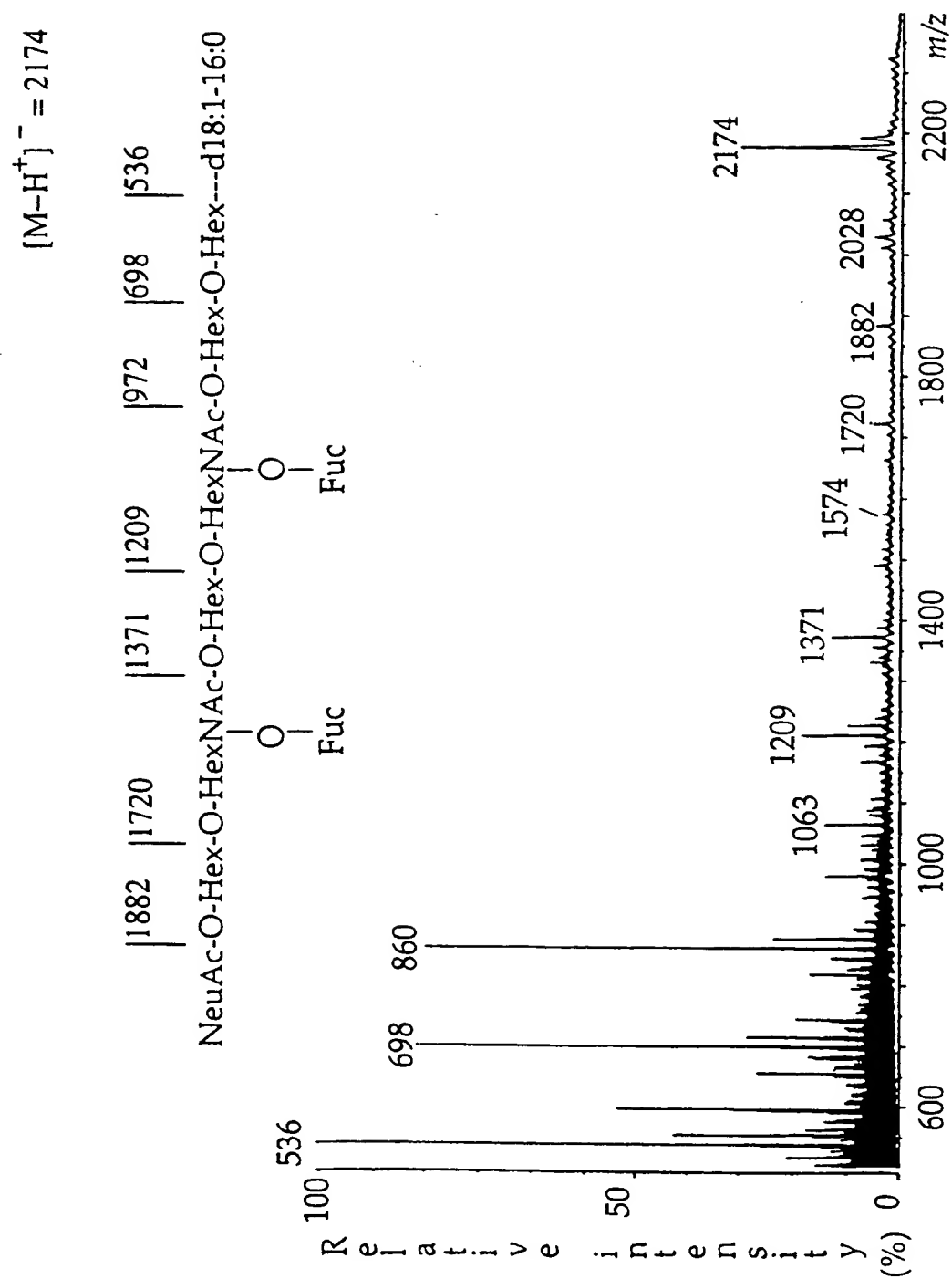Binding assay with iodine labeled conjugate

1. Lewis b
2. Sialyl-Lewis x
3. Sialyl-Lewis a
4. 3´-Sialyllactose
5. 6´-Sialyllactose
6. 3´-Sialyl-N-acetyllactosamine (3 atom spacer)
7. 3´-Sialyl-N-acetyllactosamine (14 atom spacer)
8. Lewis y (DS)

Fig. 4

$[M-H^+]^- = 2174$

|1882 |1720 |1371 |1209 |972 |698 |536
NeuAc-O-Hex-O-HexNAc-O-Hex-O-HexNAc-O-Hex-O-Hex--d18:1-16:0
                    O   O
                    | |
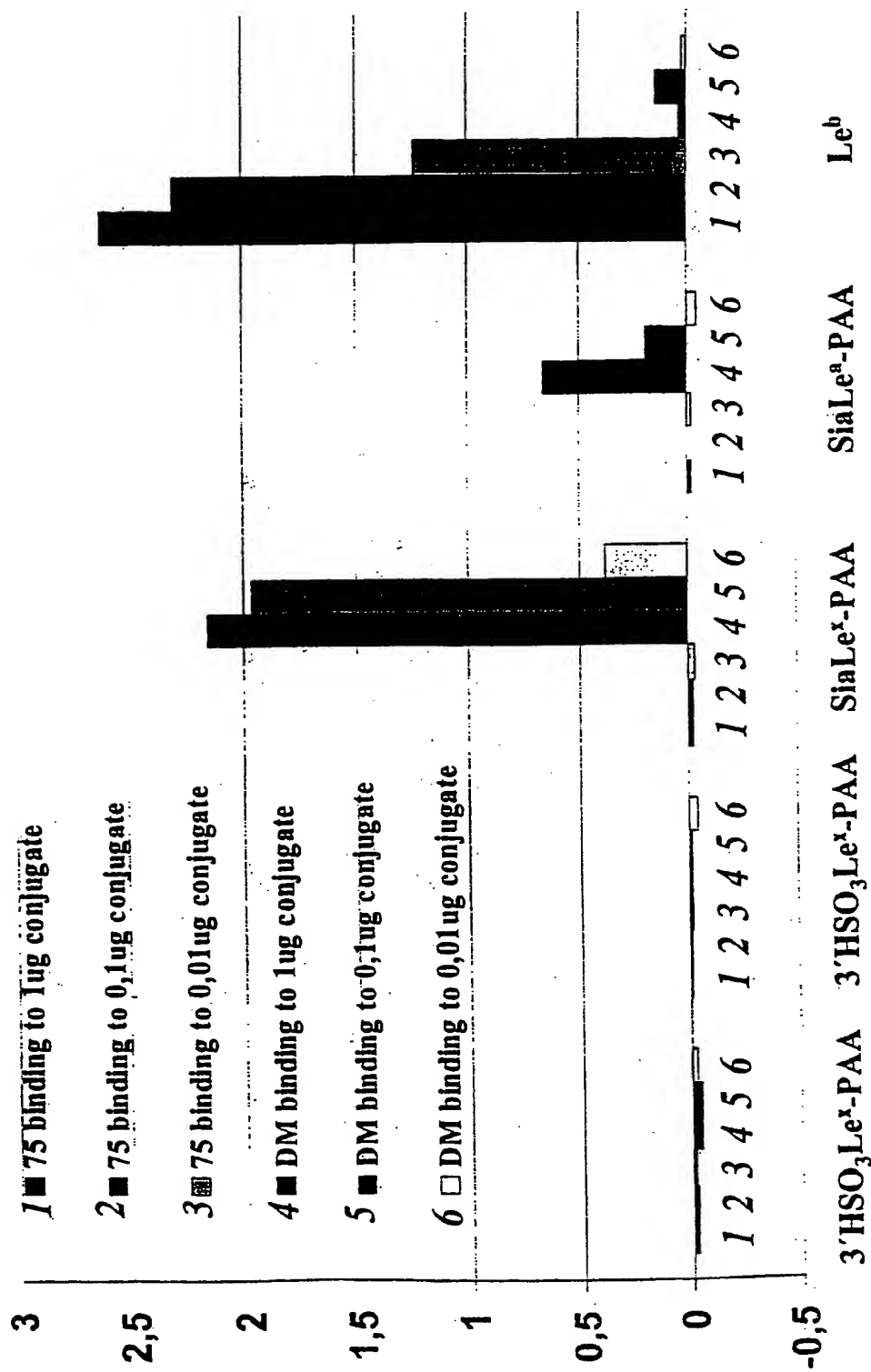   Fuc   Fuc

Fig. 5

Fig. 6 CCUG 17875 and *bab$_{A1A2}$* double mutant binding to PAA-conjugates

Inhibitions Assay, In Situ; CCUG17875 and Dubel mutant, TB12, 17/3-99
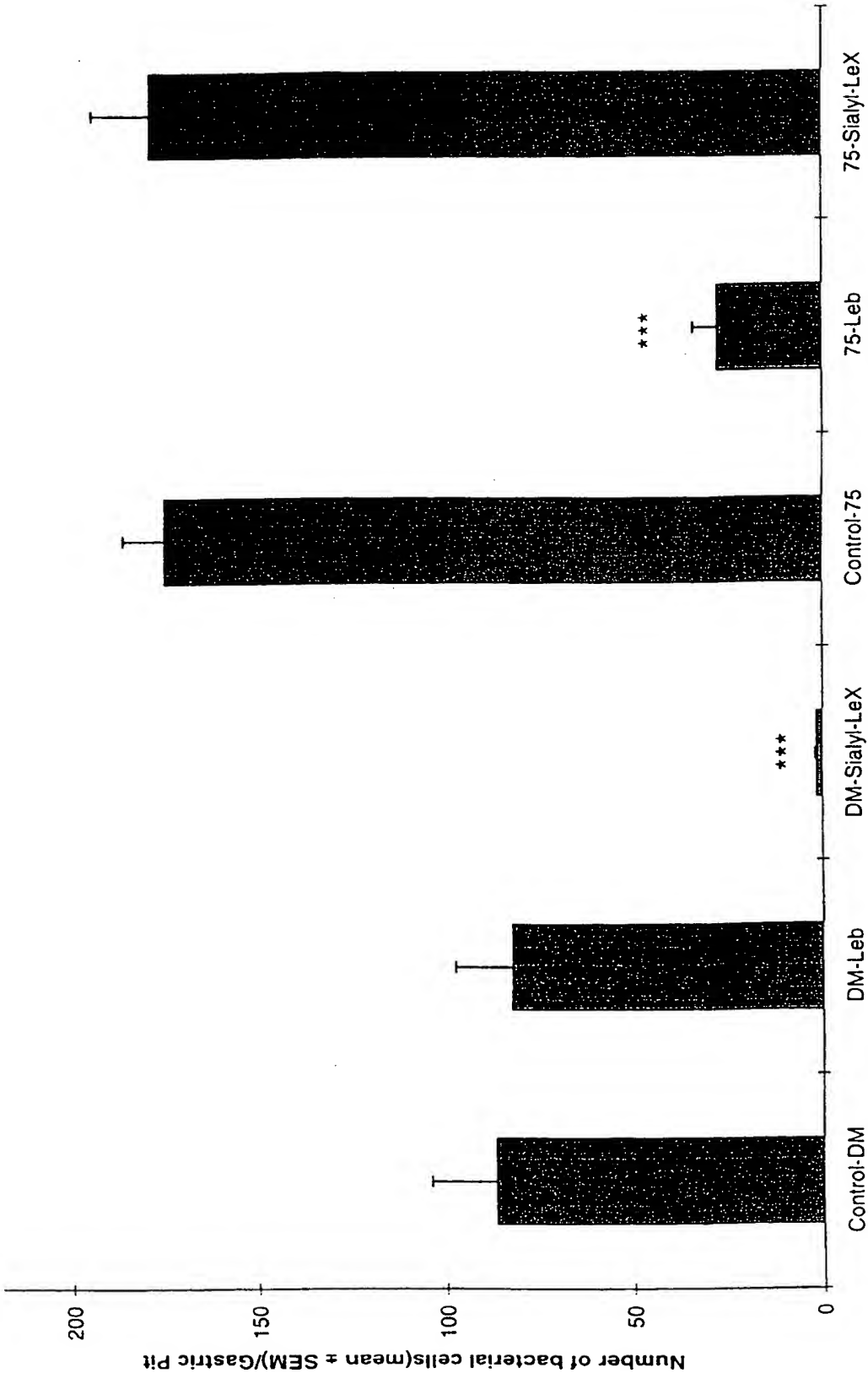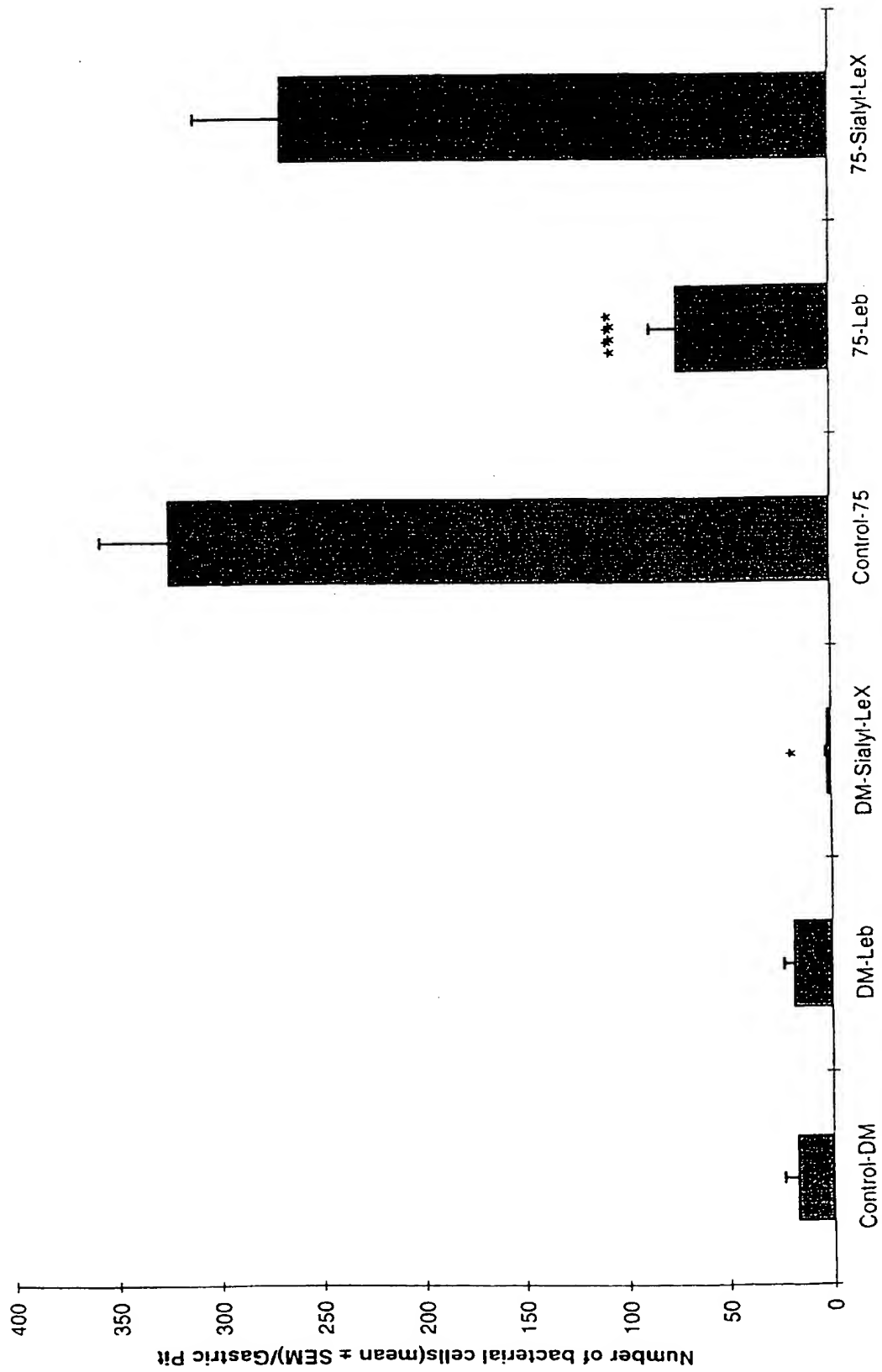
Fig. 7A

Inhibitions Assay; CCUG17875 och Dubbel Mutant-TB9 17/3-99

Fig. 7B

Inhibitions Assay In Situ;Transgenic mice; CCUG17875 and Dubel Mutant, 17/3-99
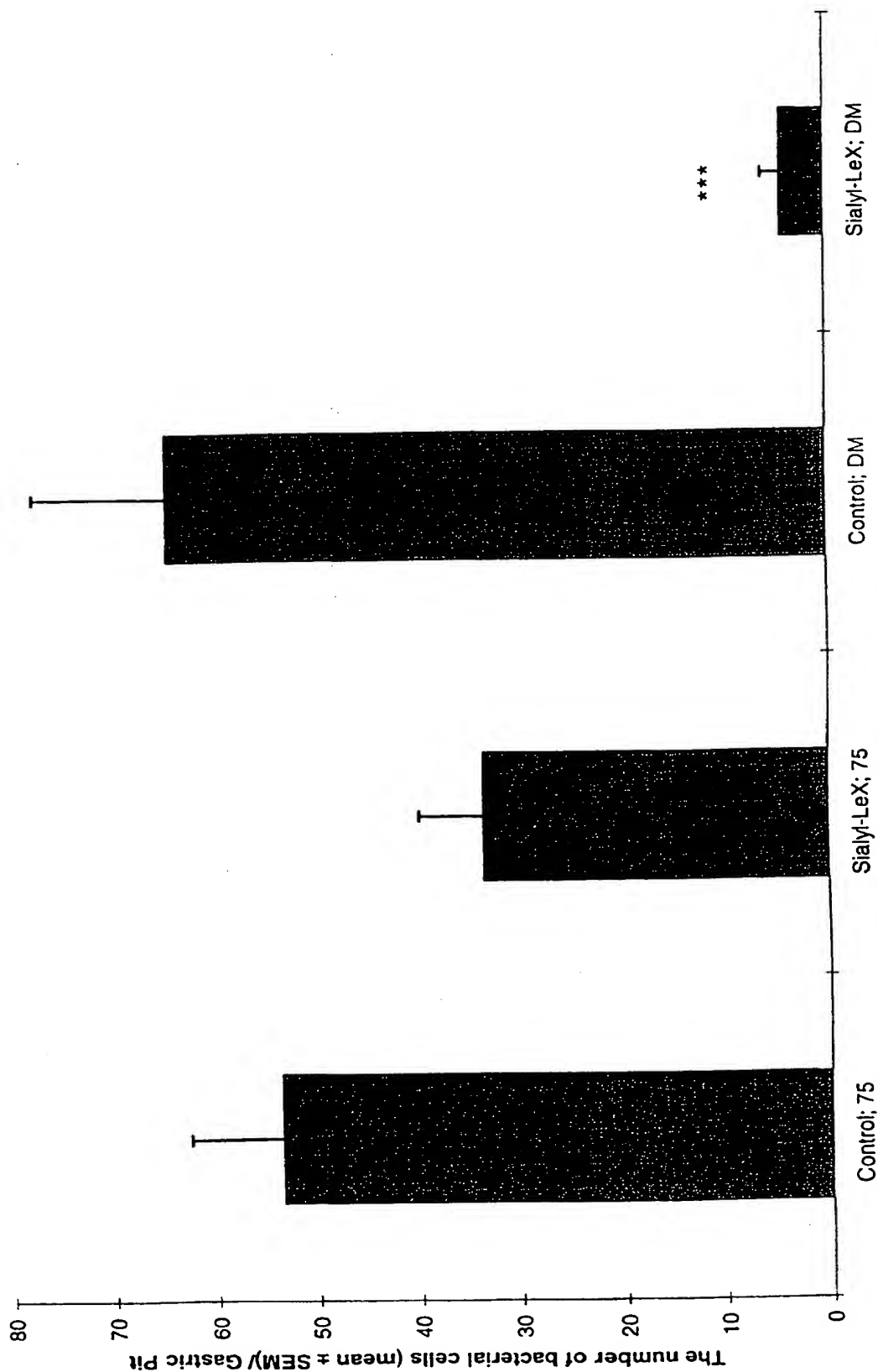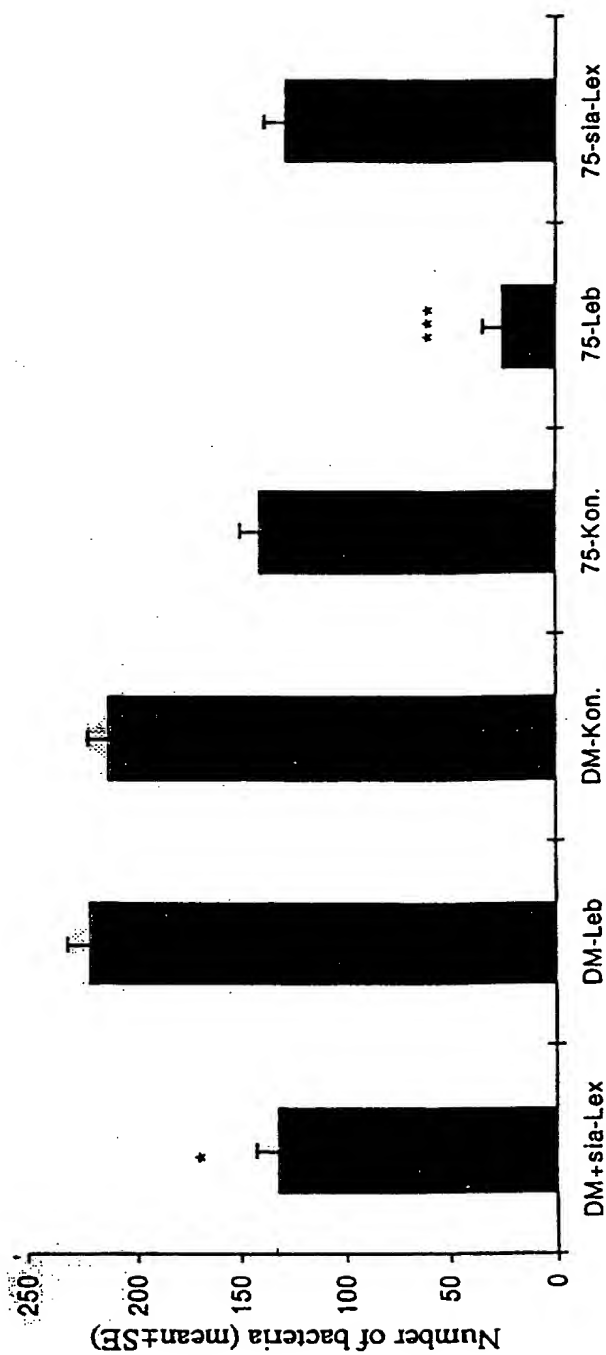

Fig. 7C

Number of bacterial cells/Gastric pit

Fig. 8

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A61K 31/702, A61K 31/715, A61P 1/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A61K, A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9500527 A1 (ASTRA AKTIEBOLAG), 5 January 1995 (05.01.95) --	1-14
A	Virchows Arch, Volume 433, 1998, Hiroyoshi Ota et al, "Helicobacter pylori infection produces reversible glycosylationc hanges to gastric mucins" page 419 - page 426 --	1-14
A	WO 9523605 A1 (NEOSE PHARMACEUTICALS, INC.), 8 Sept 1995 (08.09.95) --	1-14

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 June 2000	18 -07- 2000
Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Eva Johansson/Eö Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

International application No.

PCT/SE 00/00514

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Science, Volume 262, December 1993, Thomas Borén et al, "Attachment of Helicobacter pylori to Human Gastric Epithelium Mediated by Blood GroupAntigens" page 1892 - page 1895	1-14

INTERNATIONAL SEARCH REPORT

Box I	Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: **8-12, 14**
   because they relate to subject matter not required to be searched by this Authority, namely:

   See PCT Rule 39.1.(iv).: Methods for treatment of the human or animal body by surgery or therapy, as well as diagnostic methods.

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).:

Box II	Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest   ☐ The additional search fees were accompanied by the applicant's protest.

                           ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/00514

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO 9500527 A1	05/01/95	AU	7089194 A	17/01/95
		CA	2164961 A	05/01/95
		EP	0706528 A	17/04/96
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